5 Management of Forested Lands Controlled by DCR/DWSP

5.1 History of Land Management on the Ware River Watershed: 1927-1980

The majority of the present Division holdings on the Ware River watershed was purchased between 1927 and 1940, for drinking water supply protection. At the time of purchase, land use/land cover in the area was a combination of active agricultural land, abandoned fields, and forest land. The removal of most structures from the purchased land was completed by 1932, and the labor force was directed to plant the open agricultural lands to softwood species. This was undertaken primarily because it was believed at the time that forest growth helped regulate flooding and was essential to maintain water production and protect water quality. Approximately 1,700 acres were planted to white, red, and Scotch pine, Norway and white spruce, and European larch between 1931 and 1945. The major portion of this acreage was planted with red pine, with lesser amounts of the other species. Some areas were planted with combinations of these species. Red pine was chosen because it is less susceptible to white pine blister rust and white pine weevil, because it was easier to propagate in the nurseries, and because it grows rapidly and is somewhat self-pruning. In plantations where red pine was interplanted with other species it generally expressed dominance and out-competed these other species.

During the 1940s, the MDC, in conjunction with the U.S. Department of Agriculture, undertook a program to eradicate white pine blister rust. A crew was assigned to remove all currant and gooseberry bushes within the watershed, which serve as alternate hosts for blister rust. Due to these efforts and natural controls, blister rust is a very minor problem on the watersheds today.

The first harvest operations conducted on Division-controlled lands were salvage operations of timber damaged by the hurricane of 1938. From field observations, this salvage work was extensive, but only a portion of the vast amount of damaged timber was removed. Following these salvage harvests, the first silvicultural operations began in the late 1950s. Low thinnings were conducted in a number of red pine plantations to improve growth and quality.

Continuous Forest Inventory (CFI) plots were established at the Ware River watershed in 1962 by MDC Forest and Park Supervisor Fred Hunt, who established the first CFI plots at Quabbin Reservoir in 1960. Bruce Spencer replaced Fred Hunt in 1965 and became the first MDC Chief Forester. While spending much of his time on the Quabbin watershed, the Chief Forester initiated removal of the abundant low-quality white pine at the Ware River. Management activities gradually intensified, with a continued emphasis on the removal of low quality, second growth white pine stands. Ten timber sales were marked and sold in the 1960s. Approximately 2.75 million board feet of timber were sold, producing revenues of about $57,000.

Jim Joslin worked from 1969-72 as the first full time MDC Forester for the Ware River watershed. He oversaw the completion of a forest type map during this period, used to prioritize management operations. This type or stand map located the expansive acreage of low quality pine stands that are also apparent in the CFI data. Chuck Walker, hired part-time as the next Ware River forester, continued stand improvement work from 1972-1977.

DWSP's watershed lands on the Ware River presented an enormous forest management challenge that was not adequately addressed until the MDC hired Stephen Drawbridge in 1978 to fill the function of the Ware River Forester. From this time to the present, several thousand acres of low quality pasture pine stands were treated. These were either regenerated to mixed oak/pine and oak/hardwood stands, via overstory removal cuts, or left as pine stands but improved by cutting the least vigorous or most poorly-

formed trees. These harvest cuts did not produce large amounts of revenue, but the improved vigor, increased oak component, and greater age and species diversity have collectively made the watershed forest more resistant to and resilient following natural disturbances. During the 1970s, twenty-nine timber and cordwood sales were marked amounting to 2.55 million board feet and 1,500 cords of fuelwood and providing $100,000 in revenue.

Ware River Field Headquarters

5.2 First Ware River Land Management Plan: 1980-2000

The first formal forest management plan for the Ware River was written by Stephen Drawbridge in 1983. Due to concerns over water quantity at that time, the plan focused on water yield more than this current plan. Between 1983 and 2000, slightly more than 3,000 acres were treated. About 2,300 acres received some type of partial cut. These included intermediate thinnings, first or second removal cuts in the shelterwood regeneration system, or extended shelterwood removal cuts in areas that include filter and buffer areas along wetlands and waterways.

770 acres were regenerated during the same time period. Most of this regeneration cutting was final removal cuts using the shelterwood regeneration system and included stands where some portion of the residual stand was retained (shelterwood with reserves or green retention). About 75 acres were clear cut (overstory removed in a single cutting regardless of the presence of advance regeneration) in 15 separate parcels averaging about 5 acres apiece. Most of the openings were between one and five acres with about half of the acreage coming from a single area. These silvicultural operations yielded 8.4 million board feet of lumber, 9,971 cords of fuelwood, and approximately 15,000 tons of softwood pulp from 1983 to 2000. The sale of this material grossed approximately $750,000 for the Commonwealth.

Forest composition was affected in a small, but positive way. A large percentage of the forest cover on the Ware River watershed is dominated by softwoods. Sixty-eight percent of the total volume removed during the last management period was white pine. Natural stands dominated by white pine accounted for sixty-two percent of the area regenerated, and softwood plantations accounted for another twenty-two percent. Regenerated areas contain more diverse species mixtures than the stands they replaced. Compositional variation in regenerated areas is largely determined by the cutting regime used. Most regeneration on Division properties at Ware River includes more hardwood than the stand that was regenerated, and shade intolerant species such as gray birch and poplar are common where light levels are high. There are also exceptional examples of red oak regeneration, one of the more difficult silvicultural challenges. While the effort of the period from 1983 to the present was a good start toward improving the overall vigor and quality of the Ware River forest under Division control, many stands still contain low quality white pine originating from field abandonment. Addressing these stands will remain challenging for managers in this next management period.

As a result of these past silvicultural practices, watershed protection improved during the previous management period. Many softwood plantations and low quality white pine stands were replaced with complex mixtures of hardwood and softwood, increasing species diversity and improving species-site relationships. The regeneration of 770 acres improved structural diversity across the forest, and therefore improved forest resistance and resilience. Intermediate thinnings improved forest vigor by providing increased light and growing space to residual trees.

5.3 Current Forest Conditions on the Ware River Watershed

In general, the current forest on Division lands on the Ware River watershed is made up of a range of low to high quality stands, both managed and unmanaged, with an abundance of forest regeneration. A large portion of the upland forest occurs on dry outwash and dry washed till soils, which are less productive than moist till soils, but also somewhat less sensitive to logging equipment. Some of the most productive sites are still occupied by low quality stands that developed after pastureland was abandoned.

Nearly all of the uplands controlled by the Division on the Ware River watershed are forested (99%), with the remainder in field. Ninety-four percent of the forest is more than sixty years old, and sixty percent is over eighty years old. Some older stands also have an age class that originated with the hurricane of 1938, making them two-aged. A small portion of the forest area is comprised of plantations, established by MDC personnel in the 1930s and 1940s. White, red, and Scotch pine, Norway and white spruce, and European larch were planted as monocultures or in various mixtures. Most of these plantations have been converted to open land or regenerated to natural stands. The remaining forest originated from past land use and natural disturbance. The largest portion of the forest originated from agricultural lands abandoned in the late 1800s and early 1900s. These developed as understocked white pine stands ("old field white pine") that matured into low quality mixtures of pine and hardwood. Again, most are even-aged stands, but in some there is a remnant of trees that were present in the original pasture or trees that regenerated following the 1938 hurricane, giving them a two-aged or multi-aged structure.

5.4 Continuous Forest Inventory 1979-1999

Continuous Forest Inventory (CFI) plots were established throughout Division lands on the Ware River watershed in 1962. These are one-fifth acre (~53' radius) permanent plots located at the intersections of a half-mile grid (each represents 160 acres). The plots are remeasured every 10 years. CFI plots were remeasured on the Ware River in 1979, 1989 and 1999, and are summarized here. New plots are added as land is acquired and plots that have been converted to treeless wetlands are eliminated.

Every tree greater than 5.5" in diameter at breast height (DBH) on each plot is numbered and measured for DBH and total height, and given a forest product rating (e.g., sawlog, fuelwood, wildlife tree). This product classification is a standard CFI entry, which indirectly serves as a ranking of the tree's vigor. Plots are not managed differently than the area in which they fall; if that area receives silvicultural treatment, the plot receives the same. Records are kept to distinguish trees that have been cut from those that died.

Data from CFI plots is most useful for following changes in growth and mortality rates. Health and vigor of the forest over time can also be assessed from CFI information. Basal area, the cross-sectional area of a tree stem at breast height (4.5 feet) is calculated from diameter measured at the same height (DBH). The average basal area growth for Ware River CFI plots measured in 1989 and 1999 was 1.57 square feet/acre/year. In 1999 the average diameter at breast height was less than 9.6' on 19% of the plots, between 9.6" and 15.5" on 79% of the plots, and over 15.5" on 2% of the plots. Average annual diameter growth rates for major species during the 1979-1989 and 1989-1999 periods are listed in Table 4 below (calculated only from live trees measured at the beginning and end of each decade.)

TABLE 4: DIAMETER GROWTH RATES FOR TREES ON CONTINUOUS FOREST INVENTORY PLOTS

Species	Annual Diameter Growth (inches) 1979-1989	Annual Diameter Growth (inches) 1989-1999
White pine	0.14	0.11
Red pine	0.19	0.08
Hemlock	0.14	0.12
Red oak	0.17	0.15
Black oak	0.11	0.11
White oak	0.09	0.07
Scarlet oak	0.14	0.12
Sugar maple	0.11	0.08
Red maple	0.11	0.08
Black birch	0.07	0.11
White birch	0.07	0.07
White ash	0.18	0.14
Hickory	0.08	0.04
Black cherry	0.10	0.06

The biggest change in diameter growth rates occurred in red pine. Many of the plots containing red pine have been recently harvested, so that most of the trees measured in 1989 were harvested and therefore not included in this calculation. The growth rates for most species stayed about the same or went down slightly. This may be due to the increased age of the forest. All else being equal, periodic annual diameter increment accelerates in the early years of stand development, and then declines as a forest matures.

Species distribution was calculated in 1999 from CFI plots based on 4,151 measured trees and the percent of total basal area on all plots represented by each species (Table 5). Changes result from a combination of growth, harvest, mortality, and new plots. Approximately 67% of the total basal area has steadily been composed of white pine and oaks, with more pine overall. Maples account for 16% and hemlock 6.5%. Black cherry is the most prominent of all other species, and has decreased slightly from 4.2% in 1979 to 3.7% in 1989 and to 3.5% in 1999.

Regeneration of a Pine Plantation

During the most recently measured decade (1989-1999), approximately 9% of the total basal area was harvested, while an additional 5% was lost to natural mortality. From 1979 to 1999, major softwood species declined from 52% to 46% with corresponding gains in major hardwood species. This is primarily the result of an effort to reduce the amount of pasture and plantation pine. Approximately 68% of the 1979 basal area of red pine was cut before 1989, and 30% of the remainder was cut between 1989 and 1999.

TABLE 5: CHANGES IN SPECIES COMPOSITION ON WARE RIVER CFI PLOTS, 1989 TO 1999

SPECIES	BA 1989	% of 1989 Total BA	Cut	% Cut	Died	% Died	1989 BA of Trees Alive in 89 and 99	1999 BA of Trees Alive in 89 and 99	89 to 99 Growth of Alive Trees	Growth as % of 89 Net BA	Ingrowth	Ingrowth as % of 89 Net BA	1999 Total Basal Area	% of Grand total 1999 BA	Net change in BA	Net change as % of 1989 BA
White pine	872	39%	100	11%	34	4%	738	887	149	20%	29	4%	916	37%	44	5%
Hemlock	114	5%	0	0%	0	0%	114	141	27	24%	21	18%	162	7%	48	42%
Red pine	24	1%	7	30%	1	5%	16	18	2	14%	0	0%	18	1%	-6	-25%
Norway spruce	36	2%	0	1%	2	5%	34	41	7	22%	0	0%	41	2%	5	15%
Other softwoods	13	1%	0	0%	5	38%	9	9	0	0%	0	0%	9	0%	-4	-31%
Sugar maple	11	0%	0	3%	1	6%	10	12	2	19%	1	11%	13	1%	2	19%
Red maple	365	16%	33	9%	28	8%	304	365	61	20%	28	9%	393	16%	28	8%
Red oak	301	13%	27	9%	7	2%	267	337	70	26%	7	3%	345	14%	44	14%
Black oak	37	2%	3	8%	1	1%	33	39	6	18%	1	3%	40	2%	3	10%
Scarlet oak	165	7%	12	7%	4	3%	149	190	41	27%	3	2%	193	8%	28	17%
White oak	152	7%	13	8%	6	4%	134	155	20	15%	3	2%	158	6%	5	4%
Yellow birch	10	0%	0	0%	0	0%	10	12	2	23%	3	36%	15	1%	6	59%
White birch	12	1%	1	7%	2	21%	8	10	1	18%	0	0%	10	0%	-2	-15%
White ash	16	1%	1	7%	2	14%	12	16	4	29%	2	17%	18	1%	2	15%
Hickory	11	0%	0	5%	0	2%	10	11	1	12%	2	15%	13	1%	2	19%
Poplar	11	0%	0	3%	5	44%	6	8	2	34%	1	25%	9	0%	-2	-15%
Black cherry	85	4%	7	8%	7	8%	72	83	11	15%	4	6%	87	4%	2	2%
Other hardwoods	14	1%	0	0%	3	21%	11	12	1	9%	3	27%	15	1%	1	7%
Totals	2,249	100%	205	9%	107	5%	1,938	2,346	408	21%	110	6%	2,456	100%	207	9%

5.5 DCR/DWSP Goals for Forest Management on the Ware River Watershed

In developing land management goals for the Ware River watershed, the Division considers the status of this water supply relative to other watersheds. While the Ware River is administered as part of the Quabbin Section, it has some unique features that affect these goals. It is a river diversion system that, when activated, utilizes high flows during a nine month period to supplement reservoir volumes. Water from the Ware River is diverted to the Quabbin reservoir through Shaft 11A, which by design forces a very long travel time through the reservoir before this water reaches the aqueduct intake at Shaft 12. The absence of a reservoir, limited periodic use of the water, and a prolonged time separation from the consumer has brought about a modified land management history, including the accommodation of limited secondary uses on the Ware River watershed. However, the status of the Ware River as part of the supply system has not changed. The Division continues to choose forest management options that are efficient and provide excellent water supply protection, while also addressing secondary goals for wildlife habitat and biodiversity to a somewhat greater extent than on other Division watersheds.

MGL Chapter 737, Acts of 1972 provides directions for the "conservation and regulation" of Division lands on the Quabbin and Ware River watersheds. Sections 2 and 8 of this act say:

> The natural ecology of the district shall be maintained, and it shall be conserved in its present degree of wilderness character and shall be protected in its flora and fauna in all reasonable ways to assure the balanced wildlife habitat…the commission shall make…rules and regulations…to conserve the wilderness, watershed and reservoir character of the district.
>
> Lumbering or logging operations shall be permitted within the district to the extent and for the purpose of maintaining and conserving its forests in a healthful state of natural ecological balance consistent with reservoir and watershed purposes, but such lumbering and logging operations shall not be of a tree farming nature, so called, wherein natural diversification of tree species is upset nor wherein wildlife habitat or food chain growth is adversely affected.

MGL Chapter 372, Acts of 1984, which created the Massachusetts Water Resources Authority, also created the MDC Division of Watershed Management with the principal mandate, in Section 105, to "utilize and conserve said water and other natural resources in order to protect, preserve and enhance the environment of the commonwealth and to assure the availability of pure water for future generations."

The Division interprets these legislative mandates to require the maintenance of a forest cover on the vast majority of its holdings. Because of the strong tendency of the land to return to forest if abandoned, forest cover is undoubtedly the only practical cover for large holdings in this landscape. Furthermore, Division properties provide an opportunity to maintain or increase watershed forest cover to counteract losses of forest associated with development. The question left to Division forest managers is to determine what form of forest cover best meets the Division's goals. Through a combination of research and decades of experience managing these watershed forests, the Division is continually refining the design of a watershed protection forest that best addresses its mandates.

For the period covered by this plan, the principal goals for the management of Division properties on the Ware River watershed are to:

- PROVIDE A VIGOROUS FOREST COVER, DIVERSE IN SPECIES COMPOSITION AND TREE SIZES AND AGES, AND THEREFORE ABLE TO RESIST AND RECOVER FROM DISTURBANCE AND TO RETAIN AVAILABLE NUTRIENTS.

- MAINTAIN THE ABILITY OF THE FOREST TO REGENERATE FOLLOWING DISTURBANCE.
- PREVENT EROSION OF SEDIMENTS AND NUTRIENTS FROM THE WATERSHED FOREST THROUGH CAREFULLY APPLIED CONSERVATION MANAGEMENT PRACTICES.
- PROVIDE LONG-TERM WATER QUALITY PROTECTION WITH MINIMAL INTERVENTION BY DEVELOPING A VIGOROUS, LOW-MAINTENANCE FOREST.
- COMPLY WITH OR EXCEED ALL ENVIRONMENTAL REGULATIONS GOVERNING FOREST MANAGEMENT ACTIVITIES AND WATER RESOURCES PROTECTION ON DIVISION WATERSHED PROPERTIES.
- APPLY FOREST MANAGEMENT PRACTICES THAT MAINTAIN CURRENT WATER YIELDS FROM THE WATERSHED.
- WITHOUT COMPROMISING PRIMARY GOALS FOR WATER QUALITY PROTECTION, PROMOTE THE SECONDARY GOALS OF IMPROVING THE GROWTH AND QUALITY OF THE FOREST RESOURCE, PROTECTING AND ENHANCING HABITAT FOR NATIVE WILDLIFE SPECIES, AND MAINTAINING AND ENHANCING BIOLOGICAL DIVERSITY.

The Division has determined that for watershed protection purposes, a diverse, vigorous forest cover should be maintained on the vast majority of its holdings. The forest overstory provides temperature regulation for surface, ground, and stream waters, and provides seed to regenerate the forest following disturbance. Those portions of the forest that are actively growing and assimilating available nutrients limit the export of these nutrients to the water supply. The forest understory provides uninterrupted recovery from overstory losses. The forest overstory, the forest understory, the vegetative ground cover, the thick organic mat of decomposing matter on the forest floor, and root systems interspersed within the mineral soil below all work in concert to regulate water yield and to produce high quality water.

Diverse forest cover

It is a Division goal to protect the ability of the forest cover to regenerate itself, so that it is capable of quickly recovering from disturbance. While hurricanes are potentially the most disruptive disturbance facing the Ware River watershed forest, the more frequent occurrence of other disturbances is also of concern to managers. These include the effects of insects and diseases and changes brought about by smaller scale weather events, such as localized windstorms and heavy snow or ice storms. The New England forest very aggressively regenerates following most disturbances. The major exception is in areas where browsing of the young seedlings is excessive, generally due to exceptionally high numbers of deer or other herbivores. The forest's ability to recover rapidly from disturbances will be maintained by controlling the impacts of these herbivores.

Producing and retaining a diverse forest cover addresses the Division goal to protect the water supply from undesirable chemical, nutrient, and sediment inputs in a variety of ways. First, this cover reduces the erosion potential of precipitation and minimizes overland flow. It also serves to buffer chemical impacts to water quality by maximizing water contact time with vegetation and soil components. Through the process of evapotranspiration, forests act as water yield "regulators," moderating the potential water yields of watersheds and thereby controlling the associated transport of nutrients to the water supply. Finally, forests that are actively growing are also assimilating nutrients to accumulate biomass, further reducing nutrient export to tributaries.

5.6 Current DCR/DWSP Forest Management Objectives on the Ware River Watershed

An effective forest management plan functions at many levels. Landscape, forest, and stand level objectives are pursued over various planning periods that can range from one to a hundred years and more. The levels of biotic organization, and therefore of natural resource management planning, are interdependent and hierarchical – one building on the next. Objectives at the landscape level are achieved by planning at the forest level and by acting at the stand level. Integrating objectives at various organizational levels is an essential step in planning.

The primary objective of DWSP forest management on the Ware River watershed is to conduct silviculture that develops and maintains a forest cover that best supports the production of high quality drinking water. This watershed protection forest is vigorous, diverse in species and ages, actively accumulating biomass, and actively regenerating. Because the Division's primary forest management objective is water quality protection, silvicultural treatments are designed to create and maintain vigorous forest cover that both resists and recovers from a wide range of disturbances. Improving the structure and composition of stands will reduce their susceptibility to disease, insects, and disturbance, creating a low-maintenance, persistent forest cover. In the present management period (2003-2012), treatments are planned to:

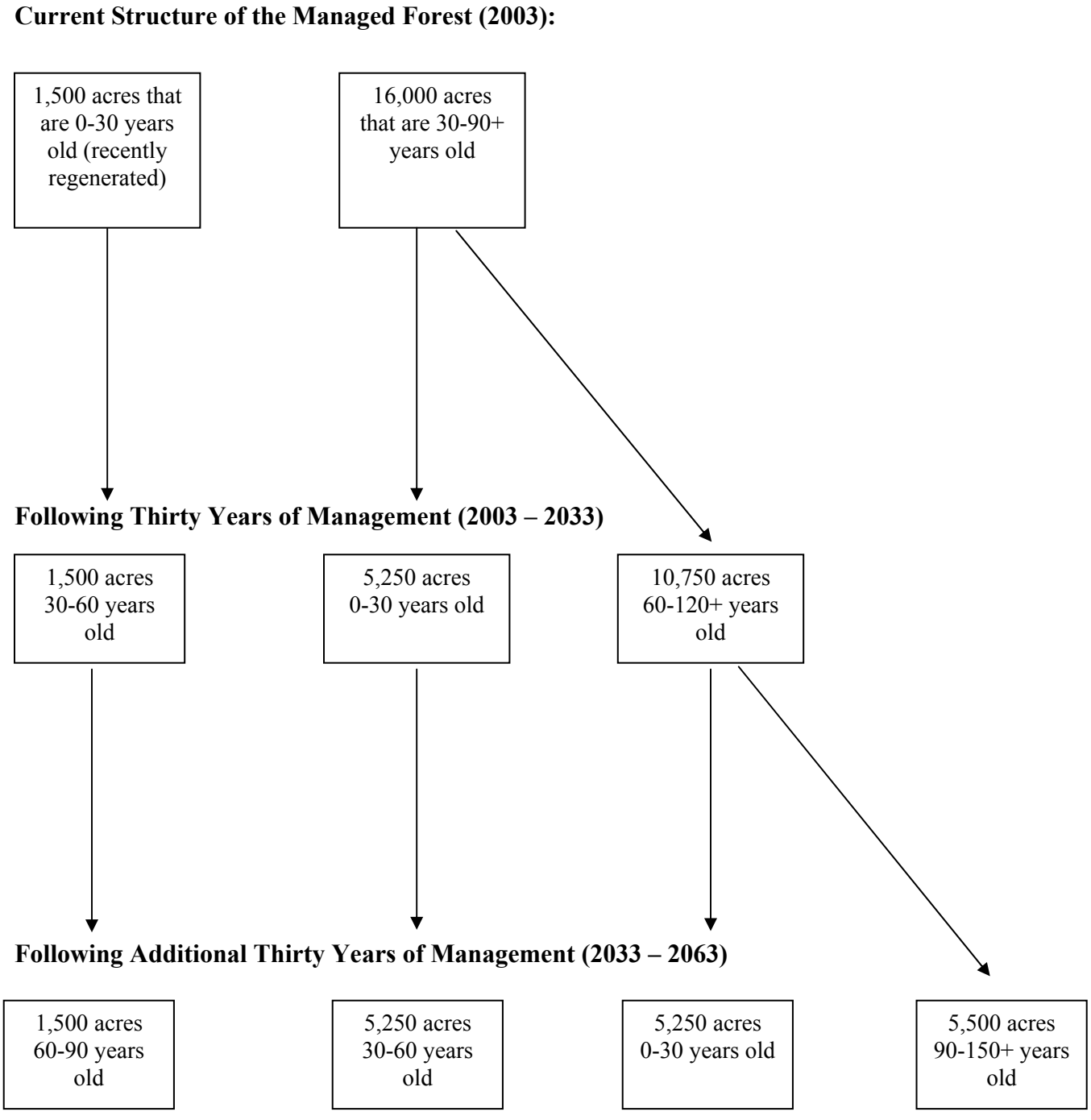
- Increase the structural diversity of the forest
- Establish regeneration as necessary, and release advance regeneration
- Regenerate approximately 1% of the managed forest annually
- Replace softwood plantations with diverse mixes of native species

While the Division's silvicultural practices over the years have produced substantial revenue that currently approaches $1 million annually, revenue production has never been a primary objective of these practices. Within this framework, Division foresters have been able to practice forestry with equal attention to harvesting and to the protection and enhancement of the resources remaining once the harvest is complete. Over decades of applying these forestry practices, the watershed forests have increased in value, both economically and as protection for the drinking water supply, without compromising their broader ecological functions.

The secondary objectives of management are generally compatible with the primary objective of fostering a watershed protection forest. The main focus of improving species-site associations and stand quality will be the conversion of stands dominated by old field white pine to mixtures of hardwood or hardwood and pine. Conversion of conifer cover to hardwoods generally enhances overall water yield. The successful regeneration of poor quality stands will produce a more vigorous and stable, higher quality, and more productive forest. In a general way, wildlife conditions will be improved by increasing species and structural diversity within the forest community. These changes will enhance biological diversity at the landscape level by creating critical areas of early successional growth.

In order to address the goal for structural diversification of the watershed protection forest, the Division will work to systematically regenerate a portion of that forest on an annual basis. 5,250 acres of the managed forest at Ware River will be converted to a new age class over the next 30 years. For this age class to become evenly distributed throughout Division land and evenly spaced through time, 175 acres must be regenerated each year. This overall approach is depicted in Figure 5.

FIGURE 5: CHANGES IN WARE RIVER FOREST AGE STRUCTURE VIA SILVICULTURE, 2003-2063



5.7 Silvicultural Practices to Address Ware River Forest Management Objectives

The application of silvicultural treatments is designed to accomplish some predetermined objective. Formation of a silvicultural prescription is based on ecological principles, but must often be altered to accommodate economic and social realities as well. Nevertheless, this prescription serves as an outline for silvicultural application, and as a means for others to understand and evaluate the silvicultural treatments applied in individual stands. There exist few absolutes in a biological system. The myriad of environmental conditions present within a forested ecosystem requires the constant attention of the forester. The ability to observe and reflect on those observations is one of the forester's most valuable skills as the person responsible for designing and implementing silvicultural prescriptions.

Each silvicultural system has advantages and disadvantages that vary with circumstances and with the objectives of management. The complexity of environmental factors present within a stand requires an individualized solution to its silvicultural needs. Application of silviculture is carried out on the stand level, and so may vary within the range of treatments available for that management area.

The guiding objective for the Division's Ware River silvicultural practices is the creation and maintenance of a watershed protection forest, defined by the Society of American Foresters as "an area, wholly or partly covered with woody growth, managed primarily to regulate stream flow, maintain water quality, minimize erosion, stabilize drifting sand or exert other beneficial forest influences" (SAF, 1983). Silviculture is the tool that provides the means to reach the objectives of management. It is the art and the science of applied forest ecology (Smith, 1993). The Germans view silviculture as a master craft which combines the thought of the scientist with the work of the craftsman (Edner, 1940). Silviculture is forest architecture aimed at the design and creation of stands with outward shape and internal construction that will serve an intended purpose, be in harmony with the environment, and withstand the loads of environmental influences (Smith, 1986). It involves the manipulation of forest vegetation to achieve a desired end, implemented within ecological principles that preserve the integrity of the biological system. To paraphrase Aldo Leopold, it is intelligent tinkering done in a manner that saves all the pieces.

A silvicultural system is defined by Smith (1997) as a planned program of treatments in a stand over the whole rotation or lifespan of the stand. Its purpose is to control the growth and reestablishment of the forest. From an ecological point of view, it is an artificial disturbance that imitates the natural processes and forces that are inherent within the forest. There are two recognized categories of treatments in a silvicultural system: methods of reproduction and intermediate or tending operations. Methods of reproduction remove all or portions of an existing stand and create conditions favorable to the establishment and growth of regeneration. Tending operations are intermediate procedures to improve composition and vigor and to optimize growth of the existing stand.

The name of a silvicultural system is commonly derived from the name of the reproduction method that is used to regenerate the stand. The reproduction methods that will be employed in managing the current Ware River forest include small-group selection cuts ranging from single trees to two acre openings, full overstory removals on up to five acres, and overstory removals with retained structure on up to ten acres. The tendency to pigeonhole a complicated and highly variable process into a pre-defined term can unnecessarily restrict the wide variety of techniques that need to be available to forest managers to address the wide variability in existing stands. "Formulation of a silvicultural system should start with analysis of the natural and socioeconomic factors of the situation. A solution is then devised…When the important act of inventing the solution has preceded far enough the less important step of attaching a name to it can be taken" (Smith 1996).

In general, this silvicultural system for the watershed protection forest at Ware River includes intermediate cuttings, regeneration establishment cuttings, and cuttings to release established regeneration.

5.7.1 Intermediate Cuttings

Intermediate cuttings are performed on stands prior to maturity, preferably when they are in the "pole" size (approximately 5-9" dbh). They are designated as "thinnings" when the objective is to remove trees of low vigor thereby decreasing competition within the stand and increasing the vigor and growth rate of the remaining trees. "Improvement" operations are designed to adjust the species and quality composition of stands. In fact, virtually all intermediate cuttings are a combination of both thinning and improvement. The defining characteristic of all intermediate operations is that there is no specific intention regarding the establishment or encouragement of regeneration; the focus is on enhancing the existing overstory.

In the Ware River forest, intermediate cuttings are rarely performed as the sole objective. Pole-sized stands are uncommon on Division property on the Ware River watershed. Some intermediate operations are performed simultaneously with preparatory and regeneration cuts (described below), including stands that are being treated for the first time without the benefit of prior management.

5.7.2 Establishment of Regeneration

There is no hard and fast rule for determining whether or not an existing level of regeneration is adequate, although Massachusetts Forest Cutting Practices regulations require 1,000 stems per acre of species well suited to the site. The Division considers at least three factors that determine "adequacy": the species composition and its site suitability; the number of seedlings/saplings per given area; and the spatial arrangement of regeneration. A high number of seedlings well distributed but of a species poorly suited to the site is considered inadequate. Conversely, a patchy distribution of a variety of species well suited to the site may be adequate if it occupies enough of the area to warrant release as a new age class.

On sites where the level of regeneration is considered inadequate, establishment or seed cuttings may be prescribed. These are designed to open the canopy sufficiently to increase light and heat levels at the forest floor thereby stimulating seed germination and seedling development. At the same time, the species composition of the overstory, and therefore the makeup of the seed sources, can be adjusted, the leaf litter can be scarified to enhance the seedbed, and competing vegetation can be reduced.

In situations where a desired species is absent from the overstory and therefore a seed source is unavailable, enrichment planting will be considered. The most common examples of this situation are dry site mixed oak stands with no white pine component in the overstory. The only practical method to establish white pine in these stands is through planting.

5.7.3 Release of Regeneration

5.7.3.1 Single Tree and Small Group Selection Cutting

Once adequate regeneration is in place, it will be released systematically to give it light and space to grow. This is accomplished by harvesting a portion of the overstory from designated stands. A relatively wide range in opening size allows for the successful regeneration of a wide diversity of species

with varying shade tolerances. In stands where species composition is well-suited to the site, and where there is not a particular concern about impending disturbances, watershed protection objectives will be met with openings ranging from single trees to patches up to two acres in size. This approach to releasing regeneration will also be applied in buffer and filter areas except that Commonwealth regulations restrict release cutting to not more than fifty percent of the basal area, and require that the remaining stand be well-distributed throughout the buffer or filter. Maximum opening size in these filters and buffers will be a quarter acre.

5.7.3.2 Variations on Shelterwood Regeneration Methods

The shelterwood method has been used successfully to establish regeneration of a wide variety of species throughout the Division properties on the Ware River watershed. The traditional shelterwood method involves gradual removal of the overstory over two or three cuttings but within the final twenty percent (or less) of the rotation for the stand. Because this method results eventually in the full removal of the overstory, it typically perpetuates an even-aged stand. However, by leaving the residual stand to grow once regeneration has been established and released, the shelterwood method can also create a two-aged stand where that is desirable. Five variations of the shelterwood method have been employed over the years by Division foresters on the Ware River watershed: the traditional shelterwood method, using one, two, or three cuts to remove the residual stand; the extended shelterwood method, in which the final removal cuts are long-delayed; the shelterwood with reserves, which uses the same procedure but retains a portion (at least 20-30 square feet of basal area per acre) of the residual stand; a two-aged approach in which one half of the stand is regenerated at a time; and the group shelterwood method, in which the stand is regenerated by first cutting small groups and then gradually expanding these groups over successive cuttings.

5.7.3.3 Full Overstory Removals

Where it is desirable to rapidly convert stands comprised of species poorly suited to the site or unstable stands of damaged or low-vigor trees, full overstory removals of limited size will be conducted. Overstory removals larger than two acres may be the desired option under the following situations:

- ***Plantations.*** A common example in which full overstory removals may be desirable is plantations (most comprised of red or white pine and Norway or white spruce). Some of these plantations were never thinned and consequently the trees are tightly spaced with short, narrow crowns. These stands are poor candidates for small openings or partial overstory removal due to the poor form and inadequate wind-firmness of the residual trees. The most practical method for regenerating these stands is the removal of larger blocks of overstory trees.

- ***Poor quality stands.*** White pine/hardwood stands that originated with the abandonment of agricultural fields and pastures are the most common poor quality stands on the Ware River watershed. White pine that grows in these open conditions frequently suffers multiple injuries to the terminal shoot from the white pine weevil, *Pissodes strobi*, which results in multi-stemmed tops with poor resistance to damage by wind, ice, and snow. Stands which originate from pastures may also be dominated by the few species that were not grazed and by poorly-formed open-grown individuals.

- ***Degraded stands***. Degraded stands on purchased land where previous landowners have high-graded stands (the highest value trees removed, leaving poor quality trees) and/or allowed poor harvesting practices (excessive damage to residual trees, incomplete removal of poorly-formed or diseased trees) are also present on the Ware River watershed. Regardless of the cause, the result

is high-risk stands of low quality, low vigor, and often physically damaged trees. An overstory comprised of such trees is not an ideal watershed protection forest. These stands often have diverse advanced regeneration that responds well to being released. Large blocks of overstory trees will be removed in order to rapidly restore these stands to a more desirable condition.

5.8 Non-Harvest Silviculture on Sensitive Sites

There are areas across the watershed where adding new age-classes in order to improve resilience is a high priority but conditions do not allow commercial operations. Examples include steep slopes and areas where soils will not support conventional machinery. On limited areas totaling less than 100 acres during this management period, overstory manipulations may be conducted without removing forest products. The Division will select only those sensitive areas where there is a clear threat of overstory loss and where this event could negatively affect a tributary or shoreline area. Examples include pine plantations with restricted access and high hurricane exposure.

The technique would remove the minimum amount of overstory to allow understory development of either native regeneration or planted trees. Efforts would be made to fell trees across the slope, and to lop the branches to reduce fire danger. This method has the advantage over natural disturbance of methodically selecting both the timing and the placement of openings, which then fill with younger age classes and "anchor" the area in the event of a major overstory disturbance. There will be negligible risks of soil disturbance or erosion in these areas as the trees will not be removed.

5.9 Strategic Approach to Forest Management and Associated Silviculture

The purpose of this plan is to outline an approach for forest resource management on Division lands to meet Division goals at all levels. An integrated approach to planning and managing presents the best strategy to accomplish multi-level objectives. Managing to assure a continuous supply of pure water is generally compatible with other goals of maintaining forest vigor, diverse wildlife habitat, and landscape level biological diversity. Maintaining all ecosystem parts and functions (biological integrity) provides stability, which ultimately provides the best resource protection.

The approach adopted for the management of the forest at the Ware River consists of three separate strategies, which will guide management in different areas. As a group these strategies give Division foresters flexible tools with which to address the primary objective of water quality protection as well as a variety of secondary concerns such as biological diversity and aesthetics. They also match the intensity of the silvicultural practices to the sensitivity of resource areas to these activities. Strategy 1 will eliminate silvicultural operations in portions of the forest. Strategy 2 will employ limited silvicultural treatments in areas where silviculture is limited by regulation, including riparian filters and roadside buffer areas. In Strategy 3, all described types of silviculture will be employed to address a range of management and habitat goals. A more detailed description of the strategies and associated silviculture follows below. Figure 6 maps these strategies across the watershed.

5.9.1 Strategy 1: Restricted Management.

5.9.1.1 Description of Strategy 1 Areas

The purpose of this strategy is to avoid the risk of negatively impacting sensitive resources and to maintain some areas with minimal human impact for aesthetic, research or conservation reasons. In

restricted areas no stand-level silvicultural operations will be conducted, although some cutting may be done for public safety or aesthetic reasons. Fire management is also an option in these strategy areas, to suppress wild fires or to maintain fire communities. The criteria used to select areas for this strategy include:

- *Open water*, which also includes shrub swamps and other non-forested wetlands.
- *Permanent forested wetlands* in which harvesting may be permitted but where the potential benefit to watershed protection is not worth the potential risks of harvesting.
- *Remnant "old growth*" stands that are to be retained in an unmanaged condition.
- *Inaccessible areas* that are difficult or impossible to access for management purposes.
- *Aesthetic and high recreation use areas.*

Approximately 5,720 acres that fall into this strategy category have been mapped on the watershed.

5.9.1.2 *Silviculture in Strategy 1 Areas*

The areas associated with this strategy have been removed from active silvicultural management for the variety of reasons described above, all of which prohibit stand-level treatments. Changes in these forest areas will primarily be the result of natural disturbance and mortality patterns. Limited cutting of trees may occur within these restricted areas. For example, if a natural disturbance creates a safety hazard along a road or recreational path, trees may be cut to reduce this hazard.

5.9.2 Strategy 2: Management Limited by Regulation.

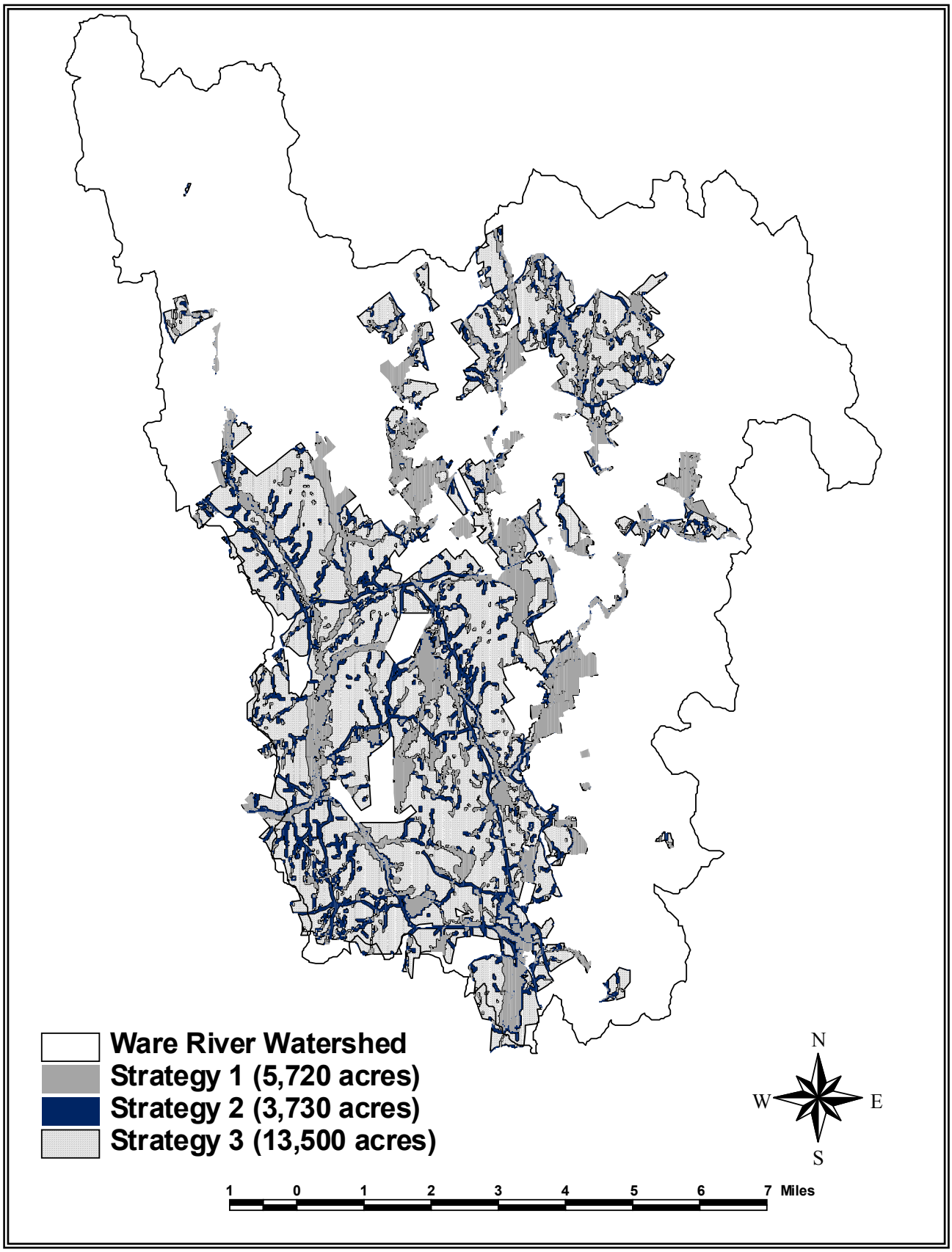
5.9.2.1 *Description of Strategy 2 Areas*

In Strategy 2 areas, existing regulations under Chapter 132, the Massachusetts Forest Cutting Practices Act, limit harvesting. Silvicultural operations will employ the partial cutting techniques allowed by law. The areas treated with this strategy are riparian filter strips and buffer strips along roadways. Commonwealth law restricts cutting to not more than 50% of the basal area in filter and buffer strips, and requires that the residual stand be well-distributed. The purpose of this strategy is to diversify forest structure at the stand level in order to increase forest resistance and resilience, to adhere to statutory regulations, and to minimize visual impacts of silvicultural operations along heavily traveled roadways. The criteria used to select areas for this strategy are:

- *Riparian filter strips* adjacent to tributaries and water bodies, which are legally a minimum of 50 feet (the Division sets this at 100 feet for all vernal pools), varying up to 450 feet depending on the slope and resource significance.
- *Roadside buffer strips* legally 50 feet back from the edge of publicly-maintained roads, 100 feet from scenic roads, with some exceptions for public safety.

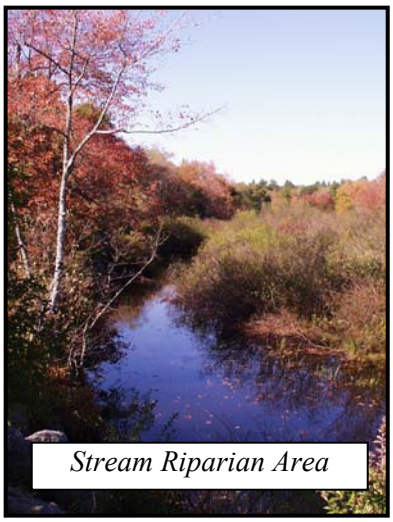
Areas mapped for the application of Strategy 2 cover approximately 3,730 acres, including an estimated 500 acres around vernal pools. Note that in mapping these areas, the Division uses a 100 foot filter or buffer as this is typically the width that is maintained, even though the minimum is 50 feet.

FIGURE 6: WARE RIVER SILVICULTURAL STRATEGY AREAS



5.9.2.2 *Silviculture in Strategy 2 Areas*

The areas that fall into this category include filter and buffer strips near water resources and roadways. The Massachusetts Forest Cutting Practices Act requires that fifty percent of the stand basal area be retained at the time of cutting in filter/buffer zones, and that the residual trees be well-distributed. This limits the silvicultural options available. Single-tree selection or the extended variation of the shelterwood regeneration method will frequently be employed in these areas when the Division seeks to diversify structure or species composition. No more than 50% of the basal area in buffer and filter areas will be removed, and openings will not exceed a quarter acre. The goal in these areas is to regenerate the stands over a long period of time to minimize impacts. Some selected stands will be managed using an extended rotation of up to 200 years to maintain an "old growth" element.



Stream Riparian Area

5.9.2.2.1 Riparian Filters

The most common riparian zone management approach that land managers take is simply to leave these areas alone. In fact, this approach has the force of law in many states, as a component of wetland protection or timber harvesting regulations. MGL ch. 131 (Wetlands Protection Act) and ch. 132 (Forest Cutting Practices Act) both contain language that restricts activities within riparian zones. The assumption behind these regulations is that their critical function in filtration of nutrients and sediments can be impaired if soil compaction and losses of vegetative cover are not carefully controlled. The Division recognizes these zones as the final and therefore most critical opportunity to control potential pollutants released by a variety of natural and human-caused events on the watersheds.

Ch. 132 requires a 50 foot minimum riparian filter for forestry purposes for all water bodies (including certified vernal pools). For Outstanding Resource Waters and their tributaries (which includes the Ware River and its tributaries), this filter strip increases with slope, up to 450 feet for a 100% (45 degree) slope. Machinery is generally not allowed to operate within the filter strip, and cutting is limited to not more than 50% of the basal area. The cutting limitation is applied to a 100 foot buffer zone around all vernal pools, certified or not, on Division watersheds. Note that the Division has mapped these areas as 100 foot filter strips along water bodies, representing the average width that is maintained (a 10% slope requires a 90 foot filter strip). In practice this strip may vary from the 50 foot minimum to the 450 foot maximum required.

The vegetative structure of riparian zones preferred by the Division is an actively growing, diverse, self-perpetuating, and disturbance-resistant forest cover. Maintaining this forest structure throughout the variety of disturbances that impact all New England forests may be best accomplished through carefully planned and implemented human intervention. To some degree, being located within the bottom of stream and river valleys shelters riparian forests from wind damage. However, as these forests mature, and especially where they are in the path of prevailing storms, they become vulnerable to sudden and dramatic damage.

Riparian forests that are simply left alone may establish regeneration as the overstory begins to age and decline in vigor. However, where full crown closure is maintained for long periods of time, understory development will be limited by low understory light and thus there will be delays in recovery following major disturbances. Through carefully implemented manipulations of the overstory and

understory, Division foresters intend to systematically "condition" certain vulnerable riparian forests to be better able to fulfill their critical buffering functions throughout significant disturbances, while avoiding soil compaction and carefully controlling the pace of silvicultural changes.

Silvicultural removals will occur within the riparian forest where soils and cutting practices allow. Where appropriate, directional felling of small groups and individual trees, without removal, will be done to bring light to the understory and stimulate regeneration where soils prevent equipment of any size. Trees will be felled perpendicular to prevailing slopes and cut into sections so that the trunk comes in contact with the ground to enhance the sediment trapping capabilities of the riparian zone. Where necessary, seedlings will be planted to enrich the understory.

These practices will be applied in:

- Areas where an important riparian area is involved.
- Areas that are exposed to significant disturbance, such as from future hurricanes.
- Areas where regeneration is sparse or absent.

5.9.2.2.2 Buffer Strips along Roadways

Harvesting practices in buffer strips along highways are regulated by Chapter 132. The objective of these regulations is to maintain a desirable aesthetic appearance along the regulated roadways. The roadways affected are publicly-maintained, except that forest management roads in federal, state, county, or municipal forests, parks, or reservations are excluded, since these are generally interior roads. The 50 foot aesthetic buffer will be maintained where Division-controlled property is adjacent to public roads, except where these roads are designated scenic roads, in which case the buffer will extend 100 feet from the edge of the road. For mapping of Strategy 2, these buffers are set at 100 feet from each side of affected roads, as they are typically maintained at this width. Cutting within these strips is limited to 50% of the basal area.

Occasionally, the Division receives a request from highway maintenance authorities to remove trees along the roadside more completely than required for buffer strip maintenance, for example if a dense conifer plantation is slowing the melting of ice from the highway surface, or a stand is frequently dropping trees in the road during high winds. The Division will accommodate these requests following consultation with the regional DCR Service Forester. This practice may result in full overstory removals within the buffer strips along short stretches of highway.

5.9.3 Strategy 3: Varied Management Options.

5.9.3.1 *Description of Strategy 3 Areas*

This strategy addresses all the land not included in Strategy 1 or 2. The full range of silvicultural options described below will be available to manage stands under this strategy. The objective is to diversify the age structure and species composition of this portion of the forest to increase resistance and resilience of the forest and to address the concerns of other demands on the land including management for biological diversity. The areas where Strategy 3 will be used include the upland sites that are located farthest from water resource areas, and total approximately 13,500 acres.

5.9.3.2 Silviculture in Strategy 3 Areas

The areas in this category are all of the forest that fall outside of the Strategy 1 and 2 areas. Silviculture will be applied according to the needs of the stand. The full range of silvicultural tools identified in this plan, from single tree selection to five-acre full overstory removal will be available, as well as limited numbers of larger openings (up to ten acres in size) with retained structure. The objectives in these areas are to protect the water supply by creating an all-aged forest, to maintain a portion of the Strategy 3 areas in early successional habitats, and to provide a range of habitats for native biota.

In addition to single-tree and small group selection cutting with openings up to 2 acres in size, this strategy area will use variations of the shelterwood regeneration method. The traditional shelterwood method, which employs two cuts to remove the residual stand; the shelterwood with reserves which uses the same procedure, but retains an element of the residual stand indefinitely; and a two-aged approach in which one half of the stand is regenerated at a time will all be employed in the treatment of stands. Full overstory removals up to five acres in size will be used in some softwood plantations to rapidly convert these areas to mixtures of native species and to create viable, though temporary early successional habitat. Shelterwood cuttings that remove all but 20-30 square feet of basal area within an area of up to 10 acres will also be employed, for instance to more rapidly convert old field white pine to mixtures of pine and hardwoods.

5.10 Predicted Results of the Three-Strategy Approach

This management approach combines several strategies to meet both water quality and diverse secondary goals. It directs management away from the most sensitive water resource areas and many of the heavy use areas. It also provides aesthetic zones along the major thoroughfares and waterways that bisect the forest unit. In addition, this management approach provides a means of tracking forest development over time to ensure that goals are being met at the forest level as well as the stand level. It also provides critical elements of biodiversity that are lacking at the landscape level, including blocks of old forests and early successional forest habitats.

Watershed Protection: This three-strategy forest management approach has been designed to provide a forested watershed that will provide excellent watershed protection. When fully implemented, about 85-90% of the forest will have a diversified age structure and species composition. The majority of the forest should be resistant to, and resilient after, disturbance. About 15-20% of the forested area at any given time will be composed of young forest that is not easily damaged by major wind disturbances. Partially cut areas and intermediate thinnings will develop an understory of advance regeneration that can replace the overstory in the event of a catastrophic disturbance event, and should produce robust, well-tapered individuals that are more resistant to wind, snow, or ice damage.

This forest management approach directs harvesting operations away from tributaries and major wetland and water resource areas. The three strategy areas will be managed with a carefully controlled silvicultural approach. Some of the Strategy 2 stands will be managed with long rotations to maintain aesthetic values. Over time, the number of active skid trails and the number of stream crossings will be held to a minimum. All proposed operations will be done with equipment on which size and season limits will be imposed to regulate its impact on the broad forest resource.

Wild Character: The wild character of these forested, undeveloped watershed properties will be perpetuated by this plan, although they will receive periodic silvicultural treatment. Approximately 25% of the forest will be removed from active management and an additional 50% will receive partial cuttings,

with some managed under long rotations. Many Strategy 1 and Strategy 2 stands are contiguous and will therefore form large areas with limited management activity.

Wildlife Habitat: The integration of different strategies in this management approach addresses the broad spectrum of environmental needs for native fauna and flora, from old unmanaged stands to young recently harvested areas, and from large blocks of uninterrupted canopy to smaller mixtures of trees of all sizes.

Forest Vigor: This management approach provides high species, structural, and spatial diversity. Diversity in a general way leads to a stable, vigorous forest condition able to respond to the variety of stresses and disturbances that will occur within an ecosystem. This diverse forest condition is accomplished by applying all the management tools available to create and maintain the wide range of conditions that suit forest growth and development. Having the ability to apply the appropriate tool to the conditions that are specific to a particular stand is critical to the success of a silvicultural prescription. The success of the prescription will determine in many cases the diversity of the stand composition and the appropriateness of its species-site association. These in turn will have an impact of the vigor of individuals in the stand, and ultimately on the vigor of the forest as a whole.

5.11 Implementation of the Three-Strategy Management Approach

Stands to be treated by Strategy 1 and 2 have been identified and mapped, and all remaining areas will be treated with Strategy 3 (Fig. 6). There are approximately 5,720 acres mapped to be treated by Strategy 1 and 3,730 acres by Strategy 2, leaving approximately 13,500 Strategy 3 acres on which the range of silviculture described in this plan will be applied (Fig. 7). The boundaries between strategy areas were chosen to be easily identifiable to ensure their integrity. For administrative purposes, Division holdings on the Ware River watershed have been divided into 50 units or compartments averaging slightly less than 500 acres in size. Compartments have been numbered 1 through 50 from southwest to northeast. Each compartment and all stands within those compartments will be visited on ten-year intervals (five compartments per year, 2,500+/- acres). Stand examinations will be conducted on these visits and the data collected will be used to prioritize stands needing silvicultural treatments. These data will be entered into a database to create long term profiles of stand and forest level change to augment the CFI system. Data collected for each stand will include:

- Stand density (basal area)
- Stand height
- Forest type
- Stand age
- Regeneration type and adequacy
- Stand condition (vigor/ quality)
- Special features (unique habitats, vernal pools, significant forest and wildlife features).

Silvicultural activities will be dispersed across the watershed to enhance diversity and aesthetic amenities by following a sequential pattern. The first year compartments 1,11,21,31,41 will be examined, with 2,12,22,32,42 examined the second year, and so on until the entire forest has been covered. This planned pattern may be disrupted by the need to address pest or weather disturbances, but will generally dictate the areas to be treated.

Priorities for treatment will be set using stand examinations in each of the five compartments. To achieve a diverse age structure, about 1% of the acreage in Strategy 2 and 3 areas will be regenerated

annually. In the areas limited to small group selection cutting, this will require treating about 2% of the area annually, because 50% of the residual stand will remain. When fully implemented, the cutting regime will balance the age structure of the forest in these areas.

Stands within Strategy 2 or 3 will be prioritized for silvicultural work as follows:

- Low quality softwood stands with high susceptibility to disturbance.
- Softwood plantations of non-native species or with high susceptibility to disturbance.
- Softwood stands with advance regeneration in place.
- Hardwood stands with advance regeneration in place.

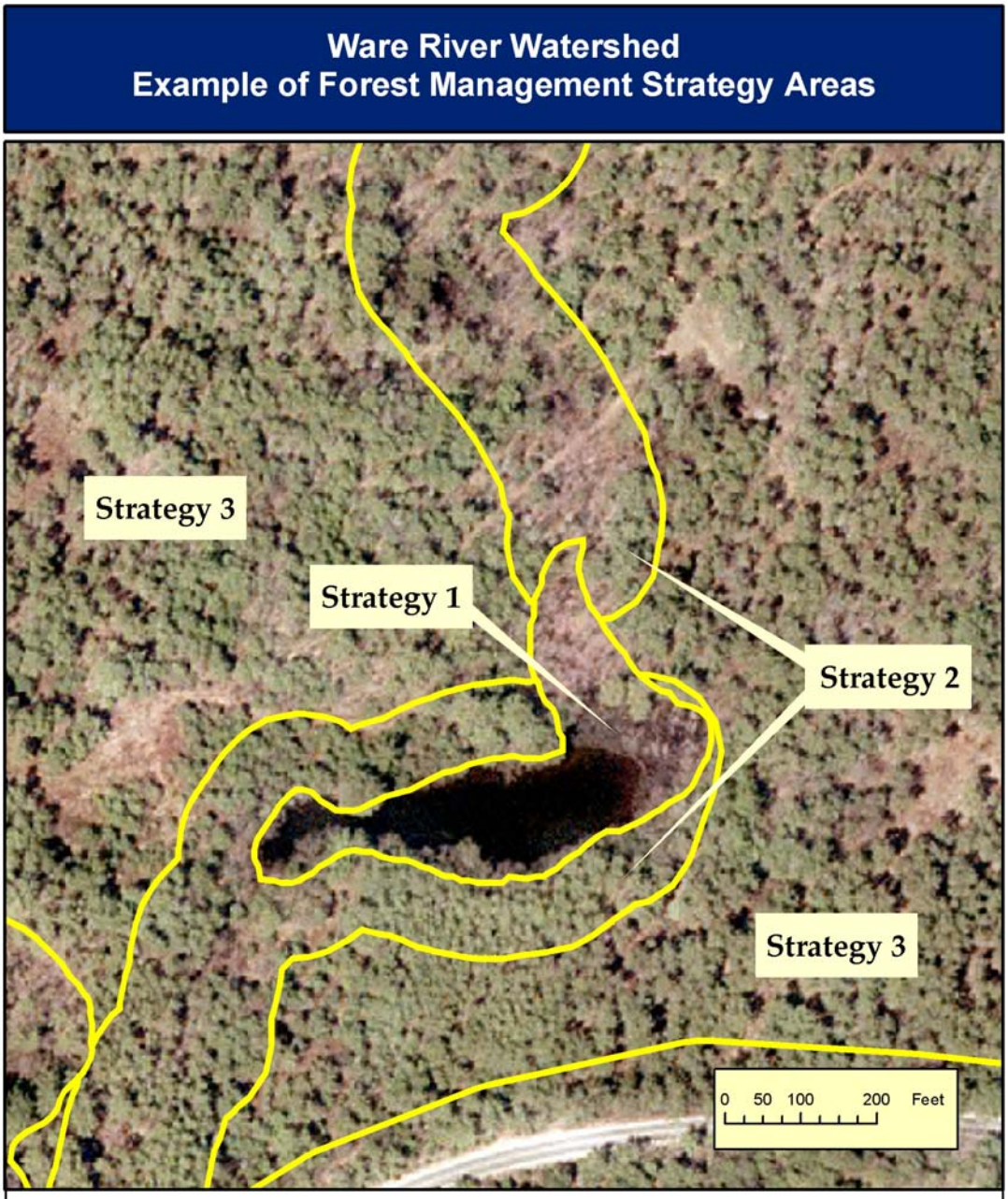
Table 6 below outlines the range of silviculture within each management Strategy, and the target objective for number of acres within each Strategy to be regenerated to create or release new age classes within the 10 year management period covered by this plan. Stand conditions at the time of inspection will determine, especially within Strategy 3 areas, the silviculture that will be applied from within the choices for that strategy. Stand conditions that will influence this decision on the ground include:

- Presence or absence of stand-wide health concerns (e.g.,a widespread presence of root-rot fungi or damage by defoliating insects).
- The silvicultural history of the stand, including recent harvesting.
- Presence or absence of advance regeneration.
- Seed source for regeneration; timing of seed production by overstory dominants.

TABLE 6: STRATEGIES, SILVICULTURAL OPTIONS, AND ANNUAL REGENERATION OBJECTIVES

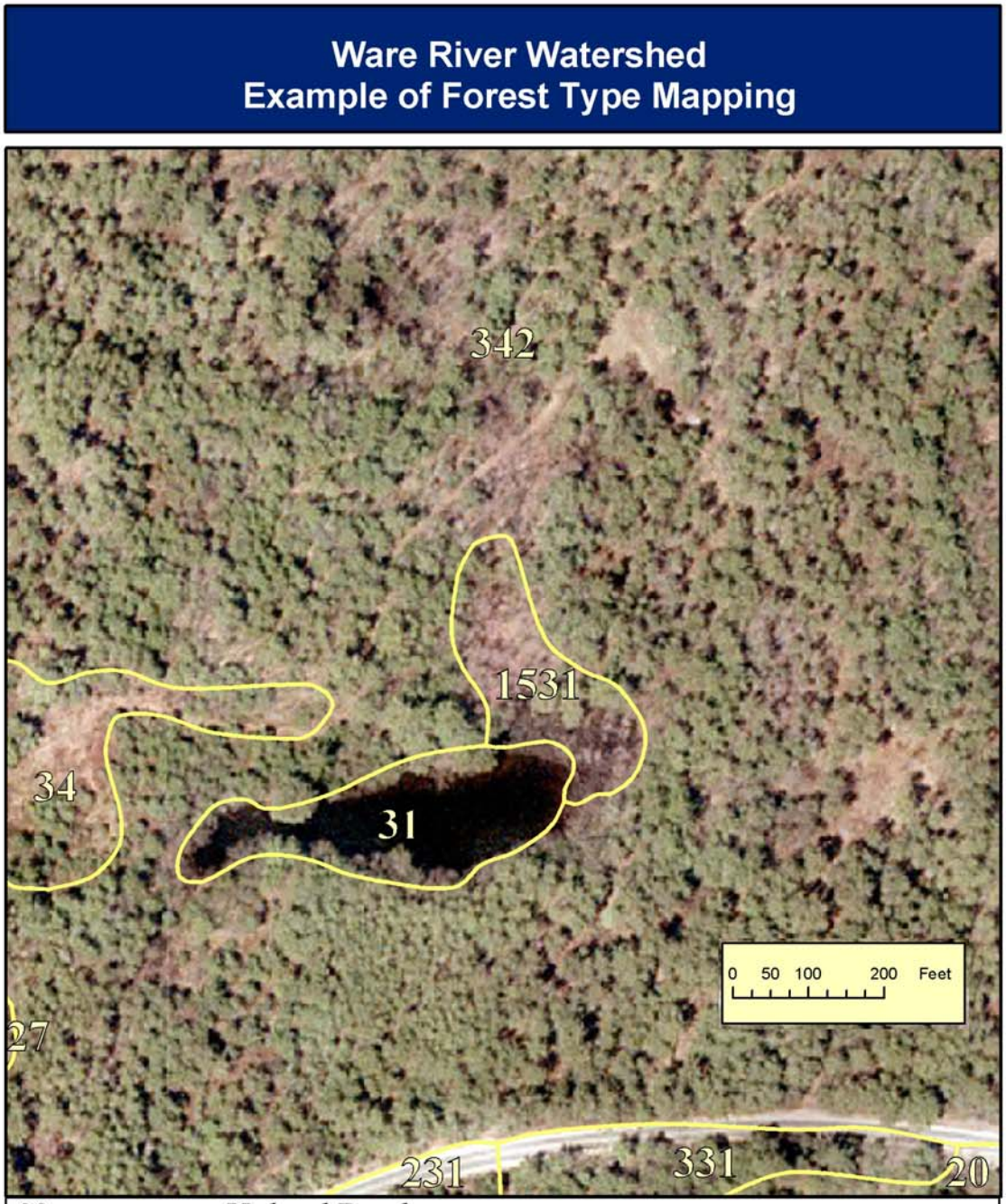
Strategy	Approximate Acreage	Silvicultural Options	Annual Regeneration Objectives
Strategy 1: Restricted management	5,720	Non-commercial cutting, non-harvest removals	Unspecified; mostly whatever nature provides
Strategy 2: Management limited by regulation (riparian filters, road buffers)	3,730	Single tree and small group selection up to 0.25 (one quarter) acre	Regenerate 40 acres/yr
Strategy 3: Varied management options	13,500	Single tree and small group selection up to 2 acres; full overstory removals up to 5 acres; overstory removals of up to 10 acres when 20-30 sq ft basal area is retained within the removal area	Regenerate 40 acres/yr using single tree to small group selection up to two acres, averaging one acre; 65 acres/yr using selection and full overstory removals up to 5 acres; 30 acres/yr using overstory removals up to 10 acres with 20-30 sq ft of retained basal area. Total 135 ac/yr
TOTAL	22,950 acres	Single tree to 5 acre full overstory removal, plus overstory removals up to 10 acres with residual structure.	Regenerate 175 acres/year, or 1,750 acres during 10-year management period

FIGURE 7: EXAMPLE OF FOREST MANAGEMENT STRATEGY AREAS



In this example, the Strategy 1 area is comprised of open water and an adjoining deciduous wooded wetland; no commercial harvesting will be planned for Strategy 1 areas. Strategy 2 areas here include a riparian filter strip of 100' along both sides of streams and surrounding the open water, as well as a 100' roadside buffer. A maximum of 50% basal area may be harvested in these areas, leaving residual trees well-distributed. Strategy 3 areas in this example include white pine/hemlock and white pine/hardwood stands of various age classes and stocking levels, as well as a gravel pit. A range of silvicultural practices will be considered for all Strategy 3 areas; stand conditions and management objectives will guide silvicultural prescriptions.

FIGURE 8: EXAMPLE OF FOREST TYPE MAPPING



5.12 Ware River Forest Types and Silvicultural Needs

The Ware River forest is a conglomerate of forest types, determined by overstory species composition, which are in turn the result of site conditions, past land use practices, and natural disturbances (Fig. 8). The major types occurring on the Division properties on the watershed are described below, as well as the silvicultural needs of these types, which will be adjusted according to the overlap between forest type and management strategy for any given stand. Where these types fall within Strategy 1, silviculture will not occur, although there may be very limited cutting for protection or aesthetic purposes. Where types overlap with Strategy 2, regeneration silviculture is limited to openings of not more than 0.25 acres in size. In Strategy Three areas, the full range of silvicultural options described above will be used to address the silvicultural needs in each of the types described below.

TABLE 7: SUMMARY OF FOREST TYPES AND ACREAGES

Forest Type	Acres
Dry site oak	737
Mesic site oak	221
White pine plantations	200
Natural white pine	1,328
Red pine type	171
Mixed hardwoods	4,023
Red maple	789
White pine-oak	1,428
White pine-hardwood	6,728
White pine-hemlock	4,325
All other types	3,000

5.12.1 Oak Type

The oak type is best divided into two sub-types based on site characteristics, dry site and mesic site oak.

5.12.1.1 Dry Site Oak Type

Scarlet, black, and white oak are the primary species along with red and chestnut oak, white pine and red maple. This type occupies approximately 737 acres, typically on excessively drained outwash soils and thin-to-bedrock till soils. Most of these forests owe their composition to a combination of past heavy cutting practices, fire history and the loss of American chestnut. These stands are typically of low vigor with slow growth rates, lacking in adequate regeneration and are the stereotypical “hotspot” where gypsy moth infestations arise.

The primary goal of management in these stands is the introduction of white pine as a component. White pine is far better suited to these sites. It is capable of superior growth than the oaks and regenerates well. There are stands where white pine exists as a scattered co-dominant, and sometimes dominant member of the overstory. These trees are highly valued as a seed source for future pine regeneration and

their ability to function in this role is enhanced by removing competing trees from around them while creating a desirable seed bed throughout the stand by partial overstory removal. Planting is a commonly used option where white pine does not exist as a seed source, and has shown good results. Pitch pine will be considered for introduction (it presently exists but sporadically and in very low numbers) into the very driest sites, where it is especially well-adapted.

5.12.1.2 Mesic Site Oak Type

These stands, which occupy approximately 221acres, are comprised of red, black and white oak with the hickories, red maple, black birch, and white pine as the most common secondary components. They are similar in origin to the dry site oak type but differ due to their occurrence on more mesic, moderately-drained sites. These stands will be converted to a greater diversity of species especially white pine and the longer-lived hardwoods such as hickory. The oaks, which are prime examples of the long-lived, low maintenance species that are sought for the watershed forest, will be maintained as a significant component.

5.12.2 White Pine Type

This type is broken into sub-types based on stand origins. Only stands that are still predominantly composed of pine will be considered plantations. Many stands that originated as pine plantations have regenerated to a mix of natural pine and a significant component of hardwoods and will be included in the discussion of natural white pine stands.

5.12.2.1 Plantations

The only definitive character of the sites occupied by white pine plantations is that there is no pattern. Plantations were established on 200 acres on virtually every soil type from xeric outwash soils to poorly drained tills. Unfortunately, the one common factor is that until the 1980s, these stands did not receive the thinning operations that planting at a six by six foot spacing necessitates.

The goal of management for all of the plantations regardless of soil type is the conversion to an appropriate, site-suited diversity of species. On the more moist sites, white pine will become a minor component in a hardwood mix. On the drier sites, white pine will persist as a significant component.

5.12.2.2 Natural White Pine Type

Natural stands that are composed primarily of white pine most commonly originate in abandoned fields and pastures. There are currently 1,328 acres of this type. The pine's relatively heavy seed, unlike the lighter-seeded hardwoods, is capable of falling through the thick grass in fields. The result is stands of nearly pure white pine in old fields, typically surrounded by stonewall. Pine that develops under these conditions is commonly attacked by the white pine weevil resulting in crooked, multiple leader stems. Such trees are more susceptible to wind and snow damage. Where these stands are heavily stocked with very limited understory development, the goal of management is to diversify the species composition, introduce new age classes and remove the individuals of poorest growth form.

5.12.3 Red Pine Type

All of the red pine in the Ware River forest was established by planting during the last century. Today, approximately 171 acres of red pine plantation remain. As was the case with white pine plantation, red pine was planted on a wide variety of soil types, many that are not well suited to the long-term development and regeneration of red pine. Red pine will grow very well on moister, more fertile sites. It is also, however, highly prone to root damage and subsequent disease problems and windthrow on these sites. Red pine is well suited to growth and development on drier soils and it is on these sites that a component of red pine will be maintained while encouraging an increased diversity of appropriate species. On the more mesic sites, red pine will gradually be eliminated as a component of the stands.

5.12.4 Mixed Hardwoods

There are approximately 4,023 acres of forest comprised of a variety of hardwood species. Red maple, white ash, hickory and red oak are the dominant species along with a component of white pine. This type is most common on mesic soils in mid- to low-slope situations and tends to grade into the red maple type as soil moisture increases. These sites are ideally suited to the growth of highly diverse stands. The focus of management will be the maintenance of this diversity, along with the establishment of new age classes.

5.12.5 Red Maple

Stands dominated by red maple occupy approximately 789 acres. Common secondary species include white pine, white ash, hemlock, red oak and black cherry. Red maple stands occupy poorly drained, wetland sites, as well as non-wetland soils on low-slope sites that support logging equipment with the use of adequate CMPs. Many of these stands are similar to mixed-hardwood stands except for the predominance of red maple, which often tends to be of poor form and vigor. Therefore, the goal of management will be the diversification of these stands at both the species and age class level. A greater component of species such as red oak, white ash, black cherry, yellow birch and hickory will be sought.

5.12.6 White Pine – Oak Type

This type is comprised of predominately white pine and red oak, white oak, scarlet oak and black oak. Many other hardwoods are associated with this type. Approximately 1,428 acres are occupied by this type on the Ware River watershed. It occurs mostly on drier washed till and outwash soils and will be maintained on these sites. The white pine component may be increased on the driest sites.

5.12.7 White Pine – Hardwood Type

White pine, red oak, and other hardwoods predominate in this type. Red maple is the chief associate. This type occupies approximately 6,728 acres on the Ware River forest. Often found on soils that are more mesic than the white pine oak type, many of the stands in this type also originated from abandoned pastures. The red oak component will be increased on the better sites through silvicultural treatments. The quality of the white pine component should increase on all sites because the stands will originate from silvicultural treatments and not abandoned pasture.

5.12.8 White Pine – Hemlock Type

White pine usually dominates this type with hemlocks in the co-dominant or intermediate crown positions. There are many associated hardwoods. Mature stands in this type often have very little understory due to the dense shade of the overstory. This type occupies approximately 4,325 acres at the Ware River. Many of these stands are in the valleys along streams and rivers. The white pine in these stands is usually of high quality due to natural pruning of lower branches by the shade of adjacent hemlocks. These stands will be opened up to develop an understory. The hemlock component will be reduced either directly by hemlock woolly adelgid mortality, or through salvage of infected trees.

5.13 The Role of Natural Disturbances on the Ware River Watershed

Natural disturbances in a forest occur at virtually all scales of time and area. The infestation of a single tree by carpenter ants, the perpetual browsing of deer, and a forest fire are all examples of natural disturbances. These disturbances, though "natural," can compromise forest structure and vigor and therefore the ability of the forest to protect water quality. It is a principal goal of the Division to insure the supply of high quality drinking water for both the short and long term. The management of the Ware River forest must be planned to mitigate negative impacts resulting from natural disturbances, both large and small scale. The most significant, sometimes catastrophic disturbance that affects the forests of Massachusetts is hurricanes. From meteorological records and forest reconstruction it has been estimated that hurricanes strike southern and central New England every 20-40 years, while catastrophic storms like those of 1635, 1788, 1815 and 1938 occur approximately every 100-150 years. (Foster 1988).

Catastrophic hurricanes have the ability to disturb a significant portion of the forest, suddenly changing species composition and age distributions. There are, however, variables that affect the extent to which a forest is impacted by various windstorms, and some of these can be controlled by foresters. A study of the Hurricane of 1938 at Harvard Forest in Petersham, MA (Foster and Boose, 1992) showed that conifers are more susceptible to windthrow than hardwoods, and tall trees are more susceptible than short trees. These two factors, in combination with the slope and aspect of any given site, are significant determinants of wind damage. In the Harvard study, conifers greater than 34 feet tall and hardwoods greater than 74 feet tall on nearly level sites (<5 degrees) or windward oriented slopes (S,SE,E) were severely damaged (>75% of all trees were damaged); there was intermediate damage (50-75% of all trees were damaged) on mild leeward slopes (5-10 degrees, N,NW,W) or intermediate orientation (NE,SW, >5 degrees). Hardwoods greater than 64 feet tall on these same exposures were damaged 51-75% and 25-50% respectively.

The structure of an uneven-aged forest, with three or more age classes well-distributed across the landscape, is designed to both resist and recover from the impacts of windstorms. Resistance is improved when much of the forest is shorter than the critical height categories according to the Harvard model. Resilience is improved when regeneration is in place and not heavily browsed in the event that the overstory is destroyed. This structure should translate to less risk to water quality in the event of a major windstorm. Fewer trees blown over means fewer trees needing to be salvaged and reduced fire hazard, and therefore a lower risk of subsequent nutrient losses to tributaries and the reservoir.

5.14 Forest Insects and Diseases

Insects and disease-causing organisms are natural components of the forest ecosystem that under ordinary circumstances play a vital role in general biodiversity, decomposition and nutrient cycling, and predator-prey relationships. On the other hand, these organisms are occasionally capable of large-scale infestation and damage, in particular when the specific organism is imported from outside the area and therefore not subject to its normal suite of population-controlling predators. Insects and diseases are a major problem in the Ware River forest only when their impacts conflict with the Division's objective of creating and maintaining a watershed protection forest. For the most part, this includes only large-scale outbreaks that threaten to alter tree species diversity or forest structure. Chestnut blight, which appeared in central Massachusetts in the first decade of the twentieth century, is an example of such a disease. Before the blight, chestnut was one of the dominant trees in the forest; today, it is essentially a minor shrub. Occasionally, an individual may grow to the status of a small tree before again being infected, dying back to the ground and perhaps putting out new sprouts.

Both the fungus that causes chestnut blight (*Cryphonectria parasitica*) and the gypsy moth (*Lymantria dispar*) are introduced organisms that came to the Ware River forest without their co-evolved complement of predators and parasites; a recipe for the development of an outbreak capable of serious disturbance of the forest's function. Other examples that have in the past affected the Ware River forest include Dutch elm disease, beech bark disease, and white pine blister rust. Native insects and diseases are generally kept in check by their predators except when cultural effects create unusual conditions. Examples include establishing species that are unsuited to the site, deliberately creating single species stands (plantations), and growing forests on soils that are nutrient depleted from a long history of farming practices.

Another significant insect threat to the Ware River forest is the hemlock woolly adelgid (*Adelges tsugae*), a small aphid-like insect native to Asia, first seen in the eastern U.S. in Virginia in 1955. Since then it has been moving up the East Coast and is presently in most towns in central Massachusetts. It feeds on hemlock at the base of the needles, removing nutrients and secreting a toxic substance in its saliva. The most recent research and observations indicate that the amount of hemlock in the forests of Massachusetts may be significantly reduced over the next decade or more. While hemlock currently comprises just 6% of the stocking of the Ware River forest, a significant proportion of it occurs in riparian zones and on steep slopes above riparian areas. This makes the loss of these hemlocks potentially more critical from a water quality point of view and also makes the commercial salvage of these areas more problematic. No extraordinary measures will be taken to salvage infested hemlock on upland sites. However, sites deemed more critical to water quality will be considered for salvage operations either through commercial or non-harvest means.

5.15 Salvage Policy

The advancing average age of the Ware River watershed forest and the steady arrival of new insect pests have lead to an increase in salvage cuttings in recent decades. In addition to insect and disease damage, disturbances include windthrow, especially of trees with weakened root structures, and ice and snow damage. Salvage activities are important components of watershed maintenance when the disturbance damages large areas of forest, or greatly increases the threat of additional damage. It is important to note that the Division does not intend to salvage following every disturbance. Many disturbances are small in scope and some are difficult to access or sufficiently remote from water resources or public use areas that they do not present significant hazards or aesthetic concerns. These

areas may be left to regenerate on their own without silvicultural intervention although in some situations they may be planted with a mix of tree species to enhance their recovery.

Removals of dead or dying trees from damaged forests can lower fire hazard (e.g., in hemlock defoliated by the hemlock woolly adelgid), allow the salvaging of timber value, and strengthen the resistance of surviving trees (e.g., by removing trees weakened by gypsy moth to improve survival of adjacent trees). The Division is aware of the importance of the steady addition of large woody debris to the forest ecosystem. However, the volume of dead and dying wood that is eventually salvaged is a small fraction of the total mortality in any given period of time. Therefore, ecosystem functions will continue to be met even while other short-term concerns are addressed through salvage efforts.

Where large areas are involved, salvage activities may preempt planned activities described in this plan. Where these watershed forests sit close to residential developments, the priority for salvage following disturbances may increase in order to improve aesthetics and reduce both perceived and actual fire danger. In addition to public pressure for a rapid response, there are often other time pressures driving salvage operations. For example, when white pine is damaged during the warm months of the year, its wood loses value rapidly due to fungal invasions that cause discoloration ("blue-stain"). Wood-boring insects also invade damaged timber rapidly during warmer months and can greatly reduce value. Where roads are blocked by disturbances in adjacent forests, there is also an obvious need to conduct salvage rapidly in order to restore access, which is critical for fire control and emergency response. In situations that involve these time pressures, review and timber harvest permit procedures may be streamlined when an operation is deemed to be salvage and conditions warrant rapid action.

5.16 Conservation Management Practices for Water Supply Forestry

Forest management at Ware River is conducted to improve the protection of the drinking water supply. Short-term impacts from forest management practices must be exceeded by the long-term benefits to water quality protection. Accomplishing this objective requires strict compliance with management practices designed to protect against losses of sediments and nutrients to adjacent water resources. Described below are specific Conservation Management Practices designed to protect water supplies, which is the standard for the Division's forest management. It should be noted that the Division meets or exceeds the requirements of both the Forest Cutting Practices Act and the Wetlands Protection Act (MGL Ch. 132 and 131). Whenever these regulations are revised, Divisions management practices will meet or exceed the revised standards.

Strict adherence to Division Conservation Management Practices (CMPs) ensures that forest management is conducted in a manner that does not impair water resources or other natural/cultural resources on the watersheds. Silvicultural practices, as described in the management plan, are employed to bring about specific forest conditions that protect the water supply. These practices require the cutting and removal of overstory trees to diversify structural and species compositions and to maintain the vigor of the residual overstory. A given forest stand is treated, on an average, every 25-30 years and at that time, 1/3 or more of the overstory may be removed to establish and release forest regeneration. The process of removing trees can impact the forest and soils essential to water quality if not carefully designed, implemented, and monitored.

Among the areas of greatest concern is the placement of forwarder and skid roads and log landings, where logging work is concentrated. Proper location of these in relation to streams, rivers, reservoirs, ponds, vernal pools, and bordering vegetated wetlands is important so that soils do not move from these areas into water or wetland resources. Beyond this principal concern, Conservation

Management Practices are designed to diminish the negative impact of silvicultural operations on the residual vegetation, to minimize soil compaction during these operations, and to keep potential pollutants out of the water resource.

5.16.1 Planning Variables

There are many variables to consider when planning and conducting a logging operation, including equipment limitations, weather, soil depth, soil moisture, topography, silvicultural practices, vegetation, and operator workmanship. Variables such as weather, soil moisture, soil depth, topography, and existing vegetation are constraints placed on logging that must be factored into planning and logging schedules. Variables such as equipment, silvicultural planning, and operator workmanship can be modified, for instance by matching allowable logging equipment with the constraints of a given site.

5.16.1.1 Logging Equipment

Logging equipment has changed dramatically in the 30-40 years that forest management has been active on Division watersheds. The primary logging machine was once the 50-70 horsepower (hp) crawler tractor-sled combination. These tracked machines were 5-6' wide and weighed 5-7 tons. Today, most logging is done with 4-wheel drive articulated skidders or forwarders with 70-100 hp, widths of 7-8 feet, and weights of 6-8 tons. Skidders drag logs attached to a rear-mounted cable and winch, while forwarders carry logs on an integrated trailer.

Other types of logging equipment include grapple skidders, wheeled and tracked feller-bunchers, and feller-processors. A grapple is an add-on feature that replaces the winch and cable with hydraulically operated grapple arms. Feller-bunchers cut trees and put them in piles, usually for removal by a grapple skidder. There are 3 or 4 wheel feller-bunchers that must drive up to each tree for felling, whereas tracked models can fell a tree 10-20 feet from the machine. A feller-processor (usually on tracks) fells, de-limbs, and cuts trees, leaving piles of logs or cordwood, which are retrieved by forwarders.

Small skidders are useful for logging on Division watersheds whereas larger 100-130 hp models, that weigh between 8-11 tons and are 8-9 feet wide, are usually too large and heavy for stand and soil conditions. Combinations of small, maneuverable feller-bunchers and forwarders, small skidders and forwarders, and small tracked feller-processors and forwarders have all worked successfully on Division watersheds. Table 8 shows typical combinations of equipment that work on various types of harvesting operations on Division properties.

TABLE 8: HARVESTING METHODS/EQUIPMENT USED ON DWSP WATERSHED LANDS

Method/Equipment	4-8' Cordwood or pulpwood	8-20' Sawlogs, fuelwood, pulpwood	Whole-tree
1. Chainsaw felling with 4WD pickup truck	√		
2. Chainsaw felling with cable skidding	√	√	
3. Chainsaw felling with forwarding	√	√	
4. Rubber-tired, four-wheeled feller/buncher with grapple skidding		√	√
5. Rubber-tired, four-wheeled feller/buncher with chainsaw limbing and forwarding		√	√
6. Rubber-tired, three-wheeled feller/buncher with grapple skidding			√
7. Tracked feller/buncher with grapple skidding		√	√
8. Tracked feller/processor with forwarding	√	√	

In an effort to specify equipment that is appropriate on specific soils and within specific forest types, the Division has determined ground pressure and width measurements for most of the equipment common to the area, and specifies restrictions, where needed, in timber harvesting permits. Widths are either from direct measurement or from manufacturer's specifications; ground pressures are based upon a formula that combines machine weight and weight of an average load of logs with an estimated footprint for the tire size specified, at an average tire inflation pressure. Examples from this rating system are listed in Table 9.

Forwarder with tracks

Rubber-tired skidder

TABLE 9: SAMPLE EQUIPMENT SIZE/GROUND PRESSURE RATINGS

Machine Model	Tires	Width	Ground Pressure
TimberJack 208	23.1 x 26	102"	4.9 lbs/sq in
JohnDeere 440C	23.1 x 26	102"	5.0 lbs/sq in
Franklin 105XL	23.1 x 26	110"	5.3 lbs/sq in
TreeFarmer C4	18.4 x 26	93"	6.5 lbs/sq in
JohnDeere 540	23.1 x 26	105"	6.6 lbs/sq in
CAT 508GR	23.1 x 26	106"	7.1 lbs/sq in
Clark 665	23.1 x 26	114"	7.9 lbs/sq in
Clark 665	18.4 x 24	104"	9.5 lbs/sq in
TreeFarmer C6	18.4 x 34	97"	10.1 lbs/sq in
CAT 518	18.4 x 34	99"	11.2 lbs/sq in


Mechanil feller

Some of the logging equipment available is too large or heavy to meet Division requirements in certain vegetation or soil conditions, and some is limited by terrain. Matching the equipment with the site conditions so that minimal damage occurs is critical to the success of watershed silvicultural activities. DWSP specifies equipment requirements for each site in its timber harvest permits. This includes machine width and ground pressure limits, as well as specific equipment requirements (e.g., forwarders). While each site has unique conditions that require the experienced judgment of the forester to predict impacts, ground pressures are generally limited to 8 pounds per square inch or less on soils that are less well-drained. Machine widths are limited in intermediate cuttings of dense, unthinned stands with moderate topography, most typically to around 8.5 feet (102").

An example of a "preferred logging system," that accomplishes Division goals under difficult conditions is a small feller-processor and forwarder combination, used for thinning dense pine plantations on a variety of soil conditions. Both machines are able to work in these conditions with minimal damage to roots, stems, crowns, or soils. In addition, these machines can successfully work around walls and foundations and do not require a landing, as logs are stacked on the roadside. This combination can also work in previously thinned stands that have an understory of young pines, with minimal damage to the young growth.

Most feller-processors are limited to stable ground conditions (few rocks and gentle slopes) and trees less than 16" DBH. In older multi-aged stands where the trees are much larger, hand felling is necessary. Multi-aged stands will always have many more stems/acre than the present even-aged stands and consequently are more difficult to work in without damaging residual trees. A combination of a

winching machine and forwarder works well in multi-aged stands. This logging system addresses the problem of damage to the residual trees associated with long skid roads.

Table 10 summarizes some of the Division's effort to match equipment and logging systems with site conditions. The methods listed in Table 10 are taken from Table 8.

TABLE 10: HARVESTING METHODS/EQUIPMENT USED IN VARIOUS SOIL/TERRAIN COMBINATIONS

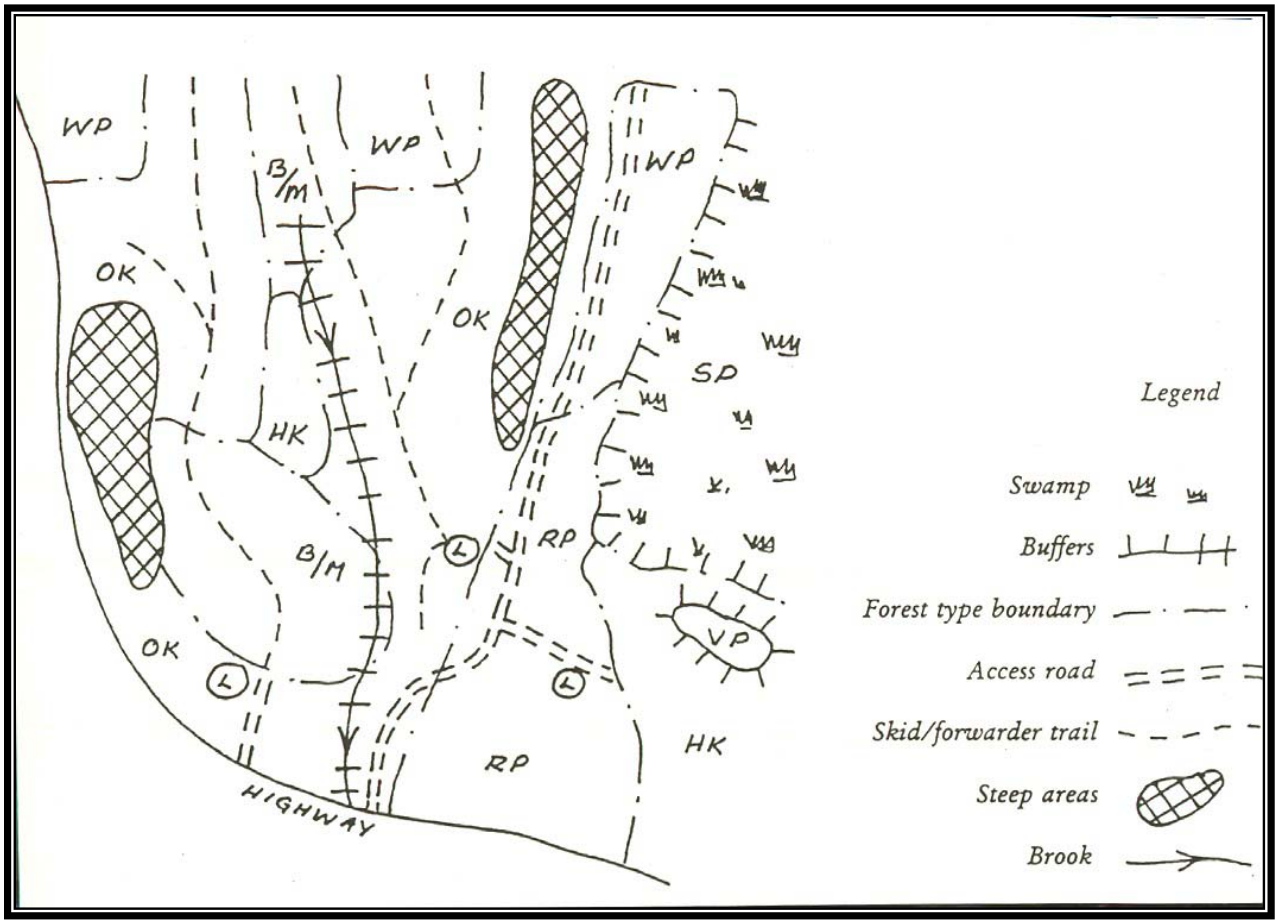
	Excessively Drained Soils	Well-Drained Thin Soils	Well-Drained Thick Soils	Moderately Well-Drained Soils	Poorly to Very Poorly Drained Soils
Level to 10% Grade	Harvesting Methods 1-8	Harvesting Methods 1-8	Harvesting Methods 1-8	Methods 1-8 with frozen or dry soils only; ground pressure < 8 lbs/sq. in	Generally not worked with machines
11-20% Grades	Harvesting Methods 2-6	Harvesting Methods 2-6	Harvesting Methods 2-6	Methods 2-6 with frozen or dry soils only; ground pressure < 8 lbs/sq. in	NA
Slopes Greater than 20%	Harvesting Method 2	Harvesting Method 2	Harvesting Method 2	NA	NA

5.16.1.2 *Silvicultural Planning*

Division land management plans have to address present and future cutting practices, landscape aesthetics, cultural resources, wildlife resources, wetlands, and rare or endangered species. The most difficult aspect of planning concerns the maintenance of multi-age stands of trees. These stands have great numbers of trees, especially seedlings, saplings, and poles that are more easily damaged than larger trees. The positioning of logging roads, landings, and small and large group cuts is crucial to the long-term success of silvicultural treatments. In turn, logging operation success is dependent upon careful advance planning (see Figure 9 for an example of silvicultural planning).

A well-planned harvest

FIGURE 9: HYPOTHETICAL EXAMPLE OF SILVICULTURAL PLANNING



This approximately 200-acre area of Division forest contains separate stands of white pine (WP), hemlock (HK), birch/maple (B/M), oak (OK), spruce (SP), and planted red pine (RP). A fire in 1957 severely burned the lower 1/3 of the area, and the red pine was planted shortly after this fire. The topography and hydrography of the area include large areas of well-drained sandy soils, but also several small steep areas, a year-round brook, a swamp, and a vernal pool (VP). These areas are delineated with buffers where required. Work within these areas is restricted; steep areas and muck soils are not worked, and buffers are only worked on frozen or dry ground. Fairy shrimp and mole salamander eggs have been found in the vernal pool, verifying its importance to wildlife. No work is proposed adjacent to this pool.

Except for the steep and wet areas, all the stands have received preparatory cuttings within the past 25 years, and the understory has developed in response. Additional work in this area will release advance regeneration by removing patches of overstory trees averaging 1 acre in size. Where understory species diversity is limited, further preparatory cuttings will occur, as well as enrichment plantings of appropriate species. Primary access is across the permanent road shown by a double dashed line. Single dashed lines are skidder and forwarder roads that have been used in the past and seeded and drained to prevent erosion. Landings are designated by a circled L, and represent areas used in the past and maintained as wildlife openings between operations. These roads and landings will be used again in current operations, and then returned to grass. There is evidence that the landings have been used between operations by wild turkey.

5.16.1.3 Operator Workmanship

Operator workmanship is one of the most crucial and variable factors in forestry operations. Good planning and preparation can be negated if operators perform poorly. Most loggers are paid on a piecework basis. Their paycheck does not always relate to how hard or how carefully they worked, but on the amount of wood that gets to the mill. However, the Division maintains tight control over loggers working on the watersheds, through close monitoring and through the timber harvest access permit and associated performance bond, and exercises its right to remove operators who fail to adhere to permit standards. It is important that foresters and loggers develop mutual respect that is based upon a shared commitment to the sustainable stewardship of the land for the protection of the drinking water supply.

5.16.2 Filter Strips

Filter strips are vegetated borders along streams, rivers, or water bodies (including vernal pools) and represent the final opportunity to prevent transport of sediment or nutrients into streams or reservoirs from nearby roads or landings. When roads and landings are near water resources, filter strips are given special attention. Chapter 132 (Forest Cutting Practices regulations) requires a minimum 50 foot filter strip, in which cutting is limited to 50% of the basal area and machinery is generally not allowed (exceptions include stream crossings).

Chapter 132 regulations require increasing the filter strip based upon slope conditions and along Outstanding Resource Waters (protected public water supplies) and their tributaries, streams that are 25 feet or more from bank to bank, ponds of 10 acres or more, and designated scenic rivers. The Division meets these requirements and also increases the filter strip, based on both slopes and soils, for other areas not included in the definitions above. For example, on moderately and poorly drained soils the filter strip is increased 40 feet for each 10% increment of slope angle above 10%. On well-drained outwash and till soils the filter strip is increased 40 feet for each 10% increase in slope angle above 20%. Equipment may enter the filter strip in limited cases where streams must be crossed.

5.16.3 Buffer Strip

Buffer strips are retained and managed for aesthetic purposes along the edges of highways and public roads. Chapter 132 requires that within this strip, no more than 50% of the basal area can be cut at any one time and that no additional trees can be cut for five years. Buffer strips will be 50 feet except along designated scenic roads, where Chapter 132 requires them to be 100 feet in width.

5.16.4 Wetlands

The Division's forest management operations will comply with all the requirements of the Wetlands Protection Act, MGL ch. 131 section 40, and the Forest Cutting Practices Act MGL ch. 132 section 40-50 for cutting in wetlands (including bordering vegetated wetlands and freshwater wetlands as defined in the most current revision of Ch. 131 and 310 CMR 10.00, and as these are revised). Generally, activities that are not conducted under a Ch. 132 Forest Cutting Plan but will alter wetland resource areas (which include a 100 foot "buffer zone" beyond the water or the bordering vegetated wetland), are subject to approval through the filing of a Notice of Intent with the local conservation commission.

Vernal pool

All of the Division's silvicultural activities that involve wetland resources are conducted under a Chapter 132 cutting plan, supervised by both Division foresters and DCR service foresters, and therefore are exempt from Chapter 131 procedures. Exceptions include limited work that does not include harvesting, such as planting, pruning, and pre-commercial thinning, and maintenance of boundaries and fire breaks. All of these latter activities are defined as "normal maintenance of land in agricultural use" by Chapter 131, and are therefore exempt from its filing procedures.

Chapter 132 requires a 50 foot filter strip along all water bodies and Certified Vernal Pools, but allows harvesting in wetland areas provided that no more than 50% of the basal area is cut and the ground is only traveled by machinery when it will support that machinery (when it is frozen or dry). In addition, the Division does not allow machinery within low, flat wetland forest with muck soils that are seasonally flooded, even though statewide regulations allow work in some of these areas during frozen or dry conditions. Most of the muck soils on Division lands at Ware River are included within the designated wetlands on the watershed. The Division has identified and mapped most wetlands within the Ware River property, which are avoided when lot boundaries are drawn for proposed annual silvicultural operations. The Division also adheres to, or exceeds the statewide recommended practices for protection of vernal pools, providing a 15 foot no-cut buffer, a 50 foot no-machinery zone, a 100 foot shade zone, and a 200 foot low-ground disturbance zone (see Figure 10). This vernal pool protection is provided to all vernal pools, whether or not they have been certified.

5.16.5 Logging Practices

A primary purpose of CMPs is to prevent or minimize the movement of soil to the water resource. During a logging operation, this is most likely to occur on a landing or skid/forwarder road. In these areas, the humus layer is sometimes lost and the soils may be temporarily compacted and channelized so that water will flow over the surface instead of passing through the soil. If the road is unwisely placed on a continuous slope, rainwater will gather volume and velocity as it travels down-slope, scouring the path, removing soil, and creating a gully. If the road connects with a stream, the suspended soil may be carried much further. The result of careless logging practices can be erosion, increased stream turbidity levels, and deposition of the eroded materials downstream.

Logging practices and the human behavior necessary to avoid environmental degradation during logging are discussed in the following sections. A cutting plan still relies upon the judgment and common sense of the logger and forester to make the right decisions in order to protect the land and associated resources in a custom tailored, case-by-case manner.

A well-organized landing

FIGURE 10: TIMBER HARVESTING GUIDELINES NEAR VERNAL POOLS

Adapted from guidelines that were cooperatively developed by foresters and wildlife biologists in Massachusetts.

Vernal pools provide critical habitat for a number of amphibians and invertebrates, some of which breed only in these unique ecosystems, and/or may be rare, threatened or endangered species. Although vernal pools may only hold water for a period in the spring, the most important protective measure is learning to recognize these pool locations, even in the dry season. Foresters can then incorporate the guidelines below in their plans to ensure that these habitats thrive.

Vernal Pool and Depression and No-cut Area — *15 foot buffer around pool*

Objective 1: Maintain the physical integrity of the pool depression and its ability to hold seasonal water.

1. Keep heavy equipment out of the pool depression at all times of the year. Rutting here could cause the water to drain too early, stranding amphibian eggs before they hatch. Compaction could alter water flow and harm eggs and/or larvae buried in leaf litter at the bottom of the depression.
2. Prevent sedimentation from nearby areas of disturbed soil, so as not to disrupt the pool's breeding environment.
3. Keep tops and slash out of the pool depression. Although amphibians often use twigs up to an inch in diameter to attach their eggs, branches should not be added, nor existing branches removed. If an occasional top lands in the pool depression leave it only if it falls in during the breeding season and its removal would disturb newly laid eggs or hatched salamanders.
4. Cut no vegetation within 15 feet of the high-water mark of the pool depression. Silvicultural manipulations are limited to girdling (for instance, to enhance vigor of uncommon swamp white oak trees).

Shade Zone — *100 foot buffer around pool edge*

Objective 2: Keep a shaded condition in this 100-ft.-wide buffer around the pool depression. Amphibians require that the temperature and relativity humidity at the soil surface be cool and moist.

1. No equipment is allowed to operate within 50 feet of the pool edge.
2. Light, partial cuts that can maintain this microclimate are acceptable; clear cuts are not.
3. Understory vegetation such as mountain laurel, hemlock, advance regeneration or vigorous hardwood sprouts after a harvest will help to maintain this condition. Avoid leaving only trees with small or damaged tops, or dead and dying trees.

Objective 3: Minimize disturbance of the forest floor.

1. Operate in this area when the ground is frozen and covered with snow, whenever possible. Keep equipment 50 feet away from the pool depression and winch out logs or wood cut in this first 50 feet.
2. Avoid operating during muddy conditions that would create ruts deeper than 6 inches. Ruts can be an impediment to migrating salamanders, some of which are known to use the same vernal pools and migratory routes for 15 to 20 years.
3. Minimize disturbance of the leaf litter and mineral soil that insulate the ground and create proper moisture and temperature conditions for amphibian migrations.

Low Ground Disturbance Zone — *100-200 feet from pool edge*

Objective 4: As above, minimize disturbance of the forest floor in this area.

1. Operate equipment in this area when the ground is frozen or covered with snow, whenever possible.
2. Follow 2 and 3 from objective 3 above.
3. Locate landings and heavily used skid roads outside of this area. Be sure any water diversion structures associated with skid trails and roads do not connect to or cause sedimentation in the shaded zone or the vernal pool itself.

5.16.5.1 Landings

When determining placement and layout of landings, their size and number are minimized and they are located on soils that will support the logging equipment. Landings are permanent sites and are placed on level and well-drained ground whenever possible. Frozen soils are desirable because they support heavy trucks, but these conditions cannot be assumed to occur for more than a month or two each year. When located on moderately drained soils, landings are constructed with natural and/or man-made materials that prevent rutting and maintain a workable surface. This generally includes the use of crushed gravel, which allows water infiltration and supports heavy equipment, and may also include the use of "geo-textiles," woven road construction fabrics that prevent mixing of gravel with the soils below. Landings will not be accessed by skidder or forwarder roads that direct water into the landing. An effective barrier is maintained between the landing and access road (e.g., road ditch, hay bales) and landings are required to be smoothed and seeded after use. Also, to prevent inappropriate uses of landings, for instance as access points for illegal off-road or all-terrain vehicle use, the access to landings from adjacent roadways will be blocked with logs, stones, or a locked gate if necessary.

5.16.5.2 Skid Roads

Skid roads are designed to be reused and are therefore located on soils that can support the skidder, such as well-drained gravel or well-to-moderately-drained stony till soils. Some soils, regardless of their drainage capacity, are wet in the spring, early summer, and late fall and harvesting must be scheduled for dry or frozen conditions. Skid roads are cut out before use and limbs left in the road to protect the soil. Skid roads are relatively straight to avoid damaging roadside tree stems and roots, but they are not allowed to carry water for more than 100 feet. Continuous grades are deliberately interrupted to divert rainwater off the road. Most skid road grades are less than 10%, but in some cases, climbing grades may reach a maximum of 20%. These steeper climbing grades are limited to 200 continuous feet. Downhill skidding grades are allowed up to 30% but for no more than 200 feet on grades greater than 20%. On skidding grades greater than 20%, which are not protected by frozen ground or snow cover, tree branches will be put on the road and other erosion-control measures taken as necessary.

Skidding distances are minimized to prevent excessive wear to roads unless frozen ground, snow, or rocks protect them. Skidder width and weight requirements are tailored to site conditions. The Division has rated many commercially available skidders by taking into account their horse power, weight, load capacity, tire size, and width to determine their suitability for logging on water supply watersheds (see Table 9 for examples). Skidder width ranges from 85-114 inches and loaded ground pressures range from 5-11 lbs/sq. inch. Typically, machines with loaded ground pressures of 8 lbs/square inch or less and widths of 102 inches or less are allowed on Division watersheds. Skidding is stopped when rains or thaws make the soils unable to support skidders.

At the end of the logging operation or when work is suspended, efforts will be made to prevent access by unauthorized vehicles (such as ATV or other off-road vehicles) by blocking access with boulders, logs, or, if appropriate, locked gates. Skid roads are also stabilized to prevent erosion following the completion of the operation. The construction of water bars accomplishes this task. On slopes greater than 10%, water bars are spaced every 50 feet and on slopes less than 10%, they are spaced every 100 feet. It is sometimes difficult to regularly space water bars due to rocky conditions and lack of places to discharge water, so spacing may vary. Water bars are designed to meet two criteria:

- They must angle across and down the road to create a 3-5% pitch.
- They must discharge water to an area that drains away from the road.

A skidder can usually be used to construct water bars unless the soils are very rocky or ledgy. In rocky soils, they may have to be dug by hand. They do not have to be more than 6-8 inches deep, including the berm, unless they have to deflect more than the overland flow off skid roads (in which case depths are doubled). After completion of logging, water bars on skid roads are seeded during the growing season.

5.16.5.3 *Forwarder Roads*

Forwarder roads are located on soils that can support these machines. The layout of forwarder roads is more flexible than for skid roads because forwarders do not require straight roads. Forwarder roads can pass through the forest avoiding soft soils, trees, and sloping ground. Forwarder roads usually have less than a 5% slope with an occasional grade up to 10% for a maximum of 100 feet. Forwarder roads sometimes require rough preliminary grading to remove stumps and rocks. Forwarders were originally designed to stay on the road and pick up logs brought to the road by a skidder, but they also replace skidders when soil and/or vegetation conditions and cultural features cannot accommodate skid roads and skidder landings. In operations that combine skidders and forwarders, skidders operate the sloping and rough ground for distances of less than 1,000 feet, while forwarders operate on the more level terrain and handle long hauling distances. Water bar requirements for forwarder roads are the same as for skid roads, and unauthorized access to these roads will be blocked following the completion of the operation.

5.16.5.4 *Stream Crossings*

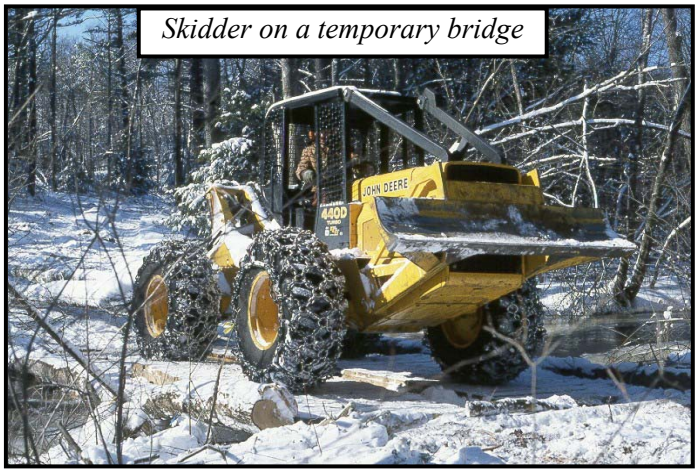
Division forestry operations cross streams on a limited basis. For example, from 1978 to 1990, the Division conducted 130 logging operations on the Quabbin and Ware River watersheds that involved twelve stream crossings. Seven of these twelve were across existing culverts, two were mitigated with approved methods, and three were crossings of intermittent streams in dry or frozen conditions. Stream crossings are frequently avoidable on Division watershed properties because the size of the property holdings often makes it possible to access a given stand from several directions. Frozen conditions are favored whenever streams must be crossed. These conditions not only protect the actual crossing but also protect the approach and limit the amount of soil carried in machine tires or on skidded logs.

Portable bridging is used to cross all streams with a continuous flow. This bridging consists of either pre-fabricated sections transported to the site (the Division has constructed portable bridge sections for use by private timber harvesters) or site-constructed bridging. Past studies (Thompson and Kyker-Snowman, 1989) have shown that machine placement and removal of crossing mitigation can move substantial sediments into the stream, especially where banks are steep or unstable. It may be preferable in some conditions to construct mitigation on-site and without machinery. In either case, the bridging will be designed and constructed so as to prevent degradation of stream water downstream of the logging activity before, during, and after that activity.

Correct siting of crossing locations is important in order to avoid soft soils that the machine may carry onto the bridge and into the water. Chapter 132 requires that all crossings be marked with paint or flagging and carefully mapped prior to filing of a cutting plan. All crossings are made at right angles to the streamflow. If frozen conditions are not available, then banks and adjacent soils are protected with tops of trees, poles, or other suitable material. In all crossings, any mitigation that involves structures that obstruct streamflow is designed and installed to accommodate the 25-year stormflow for the upgrade drainage. All temporary crossing construction is removed at the completion of the operation, and the site stabilized. Division foresters supervise the design, construction, placement, and removal of bridging or

other mitigation and the proper protection of approaches, prior to the commencement of logging on the site.

Crossings of small, intermittent streams subject to MGL ch. 131-132 protection (those portions downstream from the highest bog, swamp, wet meadow, or marsh in the drainage) are mitigated to prevent measurable downstream water quality degradation when these streams are flowing. These streams are only crossed without mitigation during frozen or dry conditions (when they are not flowing). No intermittent stream crossing will be allowed that would result in rutting or disruption of stream bank integrity. Chapter 132 further requires that all streams within 1,000 feet of the reservoir high water mark, including intermittent streams downstream of the highest wetland, must be crossed with portable bridging. Division foresters will monitor all unbridged crossings frequently and discontinue or mitigate them if conditions deteriorate and downstream water quality is threatened.



Skidder on a temporary bridge

Table 11 outlines the various stream-crossing situations encountered on Division watersheds and level of protection these crossings are given.

TABLE 11: PROTECTION MEASURES APPLIED TO VARIOUS STREAM CROSSING SITUATIONS

	Level of Protection		
Type of Crossing Situation	CMPs Only	Mitigate	Bridge
Intermittent stream, above the highest wetland in the drainage.	√		
Intermittent stream, downstream of highest wetland, when not flowing; crossing further than 1,000 feet from reservoir high water mark.	√		
Intermittent stream, downstream of highest wetland; crossing further than 1,000 feet from reservoir high water mark; when flowing.		√	
Any intermittent stream with unstable banks/approach; regardless of flow conditions.		√	
Intermittent stream, downstream of highest wetland, crossing within 1,000 feet of reservoir high water mark; regardless of flow conditions.			√
Continuously flowing stream.			√

Key: "Wetland" refers to bogs, swamps, wet meadows, and marshes. "Mitigate" includes use of poles, brush, or slabs placed in or beside a small stream to minimize equipment impacts on bank or streambed integrity. "Bridge" includes installed or site-built structures that are above the stream profile and capable of keeping all equipment and harvested products out of the profile.

5.16.6 Pollution Control

This section describes methods for control of petroleum product spills, human waste, and the disposal of rubbish generated by loggers and logging machinery maintenance.

Petroleum products: All machines are inspected by Division foresters for leaks prior to arrival and for the duration of their stay on the watershed. Checks are made of all hydraulic components, fuel tanks and lines, engine, transmission and axles. Trucks, forwarders, skidders and other equipment that carry petroleum products must have a minimum of 6 petroleum-absorbent pads (3'x 3') on the machine. Immediate action to contain and stop any petroleum spills followed by prompt notification of the forester is required. The forester in turn contacts Division Environmental Quality personnel.

All petroleum products that are not in machine storage are stored in safe durable containers and removed from the watershed at the completion of each day. Petroleum storage is only allowed in tanks designed, manufactured, inspected, and certified for commercial use. No re-fueling or servicing is allowed within the 50 foot filter strip along water bodies or within 25 feet of any wetland.

Human waste: Deposition of human solid waste is not allowed on the watershed. Permit specifications require the use of a portable bathroom facility (a minimum of a "Coleman" chemical toilet). The only exception to this policy will be the use of existing sanitary facilities on the watershed, which include those installed for recreational access.

Rubbish: All waste material, including parts, packaging, lubricants, garbage, sandwich wrappers, and other litter must be stored in appropriate containers and removed daily from the watershed.

5.16.7 Fire Prevention

Fire prevention concerns both the forest and machinery. MGL ch. 48, s. 16, a.k.a. the "Slash Law," adequately deals with the disposal of slash along boundaries, water bodies, wetlands, highways, roads and utility right-of-ways. Slash is not allowed within 25' of any stream, river, pond or reservoir. This law is also the Division standard.

Machine fires can spread to forest fires and cause water and soil pollution. Keeping a leak-free, well-maintained machine and having the proper fire extinguishers on the machine can prevent damaging machine fires. All machines are inspected for proper fire extinguisher and spark arresters by a Division forester before entering the site.

5.16.8 Protection of Residual Vegetation

Avoiding damage to roots, stems, and crowns of understory and overstory vegetation is essential in maintaining a protection forest. Damage can occur from unskilled tree felling, skidding, forwarding and the development of skid/forwarder roads. Skilled loggers and foresters can prevent most damage if the proper logging system is used. Division permits include the right to suspend operations due to operator inexperience or negligence.

5.16.9 Cultural Resource Protection

The protection of cultural resources fits well with watershed protection forestry because they both require low-impact logging systems. For example, small versatile equipment can reduce soil compaction and work around walls and foundations without damage. In many locations, there are no places for a landing due to cultural sites or poor soil conditions. Forwarders mitigate this problem by stacking logs on the roadside. The preferred logging system in these situations is a combination of cutting, lifting, or winching trees out, and forwarding them to an appropriate landing to meet cultural resource protection objectives (see Section 8 for a more detailed discussion on this subject).

5.16.10 Aesthetics

Aesthetics can be affected by all of the practices described in the above sections, and are the demonstration of quality workmanship. The maintenance of aesthetics reflects how the logger feels about the work and the land on which it is taking place. This perspective cannot be forced, but it can be encouraged and learned. When work is done correctly it is less conspicuous, but when it is done carelessly, it is obvious to all. These are public lands and the public regularly passes through them either along public roads or on roads within the watersheds. Attention to aesthetics is important everywhere, but most important along traveled ways. All slash and debris from fallen trees is kept 20' back from the road's edge or on the backside of a bordering stone wall. Landings are cleaned of unmerchantable tree debris. Care is taken to maintain large roadside trees and to promote replacement trees.

5.17 Control of Harvest Operations through Timber Sale Permit

In conducting silvicultural operations that require the removal of forest products from the forest, Division policy is to protect water quality as well as watershed resources such as soils, residual trees, and cultural resources. The Chapter 132 Forest Cutting Plan, the Division timber sale permit (discussed below), and the Conservation Management Practices presented in the preceding section address these concerns. In general, the timber sale permit specifies the performance standards, whereas the CMPs explain how these permit specifications are met.

The Permit consists of written specifications, pages detailing the forest products offered for sale, maps delineating the sale area, and a proposal page where a bid for the timber is entered and signed. The written specifications deal most directly with protecting watershed resources. Specifications consist of four parts: a.) General Conditions, b.) Water Quality Specifications, c.) Harvesting Specifications (including utilization, silviculture, and equipment requirements), and d.) Bidding and Bond Specifications. Parts b. and c. pertain to protecting watershed resources.

5.17.1 Water Quality Specifications

Water quality specifications are primarily concerned with petroleum leaks and spills and control of human waste. Petroleum products are required to be kept in suitable containers and removed from the work site each day, unless stored in tanks designed for fuel, such as those on the logging equipment. Oil absorbent pads and blankets are required on site and with all equipment, in order to intercept and immediately control a petroleum spill, should one occur. All associated refuse from maintenance and

repair is required to be stored in appropriate containers and removed from Division lands as soon as possible. Human waste is required to be deposited in Division toilets or toilets supplied by the operator.

5.17.2 Harvesting Specifications

Harvesting specifications are concerned primarily with the process of cutting trees and removing forest products from the forest. Division timber harvesting permits specify conditions for lopping slash to enhance decomposition and reduce fire hazards. Specifications are described for keeping slash out of streams and back from access roads. The penalty for cutting unmarked trees is set at three times the value of the tree. Utilization standards are specified in each permit in order to limit slash (by indicating the maximum diameter of slash that may be left in the woods). There are also specifications to limit damage to residual trees and soils, especially in the felling and removal of forest products. Locations for logging roads and landings are determined by the Division forester and delineated in the field and on the approved cutting plan; the permit specifies the condition in which these areas must be left at the completion of the operation. The permit makes it clear that the logging operation may be suspended due to wet or extremely dry conditions, at the forester's discretion.

Equipment specifications limit the size of skidders and other equipment to minimize soil compaction and rutting and to minimize physical damage to residual trees and cultural resources. These specifications may require specific equipment due to the conditions of the lot. For instance, where it is difficult to place straight skid trails, or where dense regeneration is present, the forester may specify that a forwarder must be used and that skidders are not allowed. Where hauling distances to a truck landing are long, but the lot itself requires skidding, the forester may require that both pieces of equipment must be used. The Division also may require a tracked feller-buncher-processor on lots that have sensitive cultural resources requiring specialized tree removal, on soils that cannot support heavy equipment, or in stands with heavy forest stocking that cannot be thinned properly with standard equipment.

5.18 Internal Review and Monitoring of Forest Management Operations

The key to the proper protection and management of the resources under the care and control of the Division is its staff, and the care and expertise they bring to their work. Because the foresters walk each acre of land on which forest management occurs, the management controls enforced by this staff are of paramount importance. As the on-the ground implementers of the Division's land management plans and policies, the foresters' knowledge of, and sensitivity to the various aspects of the watershed management plan have a direct bearing on the ultimate success of the program. However, it is impossible for any one individual to assimilate all aspects of the diversity of knowledge in the evolving fields of natural and cultural resource management. Therefore, the second key to implementing sensitive management is in-house review by specialists in the various key disciplines of study in natural and cultural resources, and effective communication between these specialists and the forest managers.

Within the Division, these supporting disciplines include wildlife biology, forest planning, water quality and environmental engineering, civil engineering, and cultural resource protection. Experts available outside the Division include rare species botanists and zoologists (Massachusetts Natural Heritage and Endangered Species Program) and cultural resources specialists (Massachusetts Historic Commission). The Division also has available a wide variety of experts conducting academic research on the watersheds at any given time, in part because of the research value of the resources under the Division's care and control. These professionals and interested non-professionals who spend time

studying and exploring the watersheds, contribute invaluable observations that complement the Division's understanding of its watershed resources.

To efficiently and effectively coordinate and focus this collective knowledge towards the improved protection of the drinking water supply and other natural and cultural resources, the Division has developed the following procedure for the annual review of all proposed Division forest management activities on the Ware River watershed. These reviews are in addition to the general guidelines for cultural and wildlife resource protection.

- Each December, the Division's foresters compile a plan of all proposed forest management that could occur during the next fiscal year (July-June). The only operations not included are emergency salvage after natural events. Each January, the foresters carefully map and describe the boundaries of each planned operation so that they are readily distinguishable on the ground (where boundaries are not easy to describe, they are marked with flagging). These outer boundaries may include internal areas where logging is restricted (vernal pools, stream filter strips, etc).
- After mapping the areas where forest management is proposed, the foresters submit site maps and complete forms describing the proposed silviculture in detail to the Division Natural Resource Section. Natural Resources staff digitize the maps of the planned operations, which include proximal wetlands and previously identified critical cultural and wildlife sites, prepare area summaries of these operations, and check the overall consistency of the operations with management plan silvicultural and resource protection objectives. After reviewing the proposed operations, Natural Resources then forwards copies to the watershed Superintendent, the DCR archaeologist, and the Division wildlife biologist.
- In 1986, 1990, and 1994 consultants compiled cultural resource maps for Division watershed properties. These maps denote known and likely historic sites. This identification process has not yet occurred for the Ware River watershed, although a proposal is being considered to continue this work. Once these resources are identified, and where forest management is planned for areas containing or likely to contain cultural resources, the Chief Archaeologist will identify types of activity that could damage these resources, such as soil compaction or disruption of existing structures such as walls or foundations. The Chief Archaeologist may also make recommendations for removing trees that threaten existing historic structures, and identifies areas of high, moderate, or low probability of containing prehistoric occupation sites. With these concerns in hand, the foresters modify timber-harvesting approaches as needed to protect these resources.
- Each spring, the Division's wildlife biologist reviews the planned forest management operations. Where necessary, the wildlife specialist conducts site examinations. Landscape level wildlife changes over long time spans will also be tracked using an evolving set of techniques. Local knowledge of state rare, endangered, and threatened species is referenced, as well as the location of any critical or important habitat features in the wildlife biologist's files. After completion of fieldwork by the wildlife specialist, the foresters are alerted to any potential conflicts between the proposed work and important habitat features, keyed to flagging on the ground where necessary. Specific wildlife Conservation Management Practices are outlined in Section 6 of this plan.
- Each spring, the Division's Environmental Quality staff reviews the planned forest management and, where necessary, conducts site examinations. The Environmental Quality staff may give site-specific guidelines regarding special precautions designed to increase the protection of site water quality.

- In 1995 and 1996, the Division contracted with a professional botanist to review all proposed Division lots for the presence of rare or endangered plant species. The bulk of this plant inventory occurred during May and June, although the botanist made preliminary recommendations pending an additional survey for late flowering species, conducted in August, for a limited number of these operations. In the final reports, the botanist made specific conservation management recommendations to protect these plant populations.
- Where the review process identifies undesirable potential impacts, the foresters consult with the reviewers to design a practical solution. If there are any changes in the area to be harvested and/or in the proposed practices, the forester is responsible for notifying the Natural Resources Section in order to determine if further review is required by the changes. Once the review process is complete, the foresters lay out and mark the harvesting lots. At this time a Forest Cutting Practices Act (MGL Ch. 132) Cutting Plan is prepared (outlining skid roads and specific site impacts), which the logger is required to follow. The Forest Cutting Plan is submitted to the DCR Bureau of Forestry and copied to the local Conservation Commission. After the lot has been advertised and awarded to a private timber harvester, Chapter 132 requires DCR/DSPR staff to conduct a site visit prior to the start of the operation if wetland resources are involved. These regulations also require that DCR Service Foresters check all cutting plans against the Natural Heritage maps of rare and endangered species habitats and, if they overlap, submit these plans to Natural Heritage for review and comment.

Throughout the active operation, it is the responsibility of the forester in charge to continuously monitor compliance with water quality protection measures. In particular, these include stream crossings and work near wetlands, conditions of skidder and forwarder roads as well as main access roads, equipment maintenance, and the treatment and placement of slash. The Division "Permit to Harvest Forest Products" includes detailed specifications for each harvesting operation. During the operation, the Division reserves the right to suspend the harvesting activity if warranted by weather, soil, or wildlife conditions. Upon completion of silvicultural operations, it is the responsibility of the foresters to check for full compliance with all timber harvest permit specifications prior to the release of the performance bond and filing of final reports.

Note: a separate review process is required for proposed access road development or the opening of new gravel operations. For details of this process, see Section 4.3.3.3.